DOCTOR OF PHILOSOPHY

Risk Indicators for Dental Caries in Three Scottish Prison Populations

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Risk Indicators for Dental Caries in Three Scottish Prison Populations

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Declaration

I declare that I am the author of this thesis and have consulted all references cited. I have carried out the work of which this thesis is a record. This work has not been previously accepted for a higher degree.

Tahira Akbar

Funding and ethics statements

The original survey data in the thesis is taken from the Scottish Oral Health Improvement Prison Programme (SOHIPP) Oral Health Survey which was funded by the Scottish Government (Grant No. 120.804485). SOHIPP has ethical approvals from The National Research Ethics Service (Ref.10/S0501/10) & The Scottish Prison Service (SPS) Ethics Committee.

The interpretation and opinions expressed herein are solely my own and do not reflect the official policies or position of the Scottish Prison Service or National Health Service Scotland or the views or opinions of my employer, the University of Dundee.

Abbreviations

ADHS	Adult Dental Health Survey for United Kingdom, 1998
BASCD	British Association for the Study of Community Dentistry
CES-D	Center for Epidemiologic Studies Depression Scale (CES-D)
D_1	Decay including clinically detectable (non-cavitated) enamel caries lesions/ white spot lesions
D_3	Clinically detectable (cavitated) decay extending into dentine
DHSRU	Dental Health Services Research Unit
DMFS	Decayed, Missing and Filled Surfaces
DMFT	Decayed, Missing, and Filled Teeth
HMP	Her Majesty's Prison (United Kingdom)
ICDAS	International Caries Detection and Assessment System
MDAS	Modified Dental Anxiety Scale
NHS	National Health Service
OH	Oral Health
OHRQoL	Oral Health Related Quality of Life
SOHIPP	Scottish Oral Health Improvement Prison Programme
SPS	Scottish Prison Service
YOI	Young Offenders Institute

Mathematical terms

95% CI	95% Confidence Intervals
AIC	Akaike Information Criterion
ANOVA	Analysis of Variance
β	Beta coefficient for regression models (unstandardized values reported)
H	Kruskal-Wallis H test (also called ‘one-way ANOVA on ranks’)
$\bar{X}$	Mean
N	Number
OR	Odds ratio
p	Probability value
r_s	Spearman rank-order correlation coefficient
SD	Standard Deviation
VIF	Variance Inflation Factor
χ^2	Chi-squared
Z	Z statistic from two-sample Wilcoxon rank sum (Mann Whitney) test

This thesis is dedicated to

my mother, sisters, and brothers.

Thank you for your endless support and sacrifices.

Abstract

One of the markers of the socioeconomic inequalities faced by prisoners is their experience of poorer health outcomes, including higher dental caries experience, when compared to the general population. Whilst, as a whole, prisoners are disparate there are also vulnerable sub-populations, including women, young offenders, and the elderly. There is scope to inform future health improvement programmes by characterizing how caries experience and related risk factors vary between prisoner groups. The aims of this thesis were to (1) review the literature reporting caries amongst prisoners, and (2) assess the disease burden and associated risk indicators in a population of Scottish prisoners.

Three data elements are reported: (i) a structured review with electronic searches of MEDLINE, Embase, Cinahl Plus, SCOPUS, PsychARTICLES, and ASSIA; (ii) self-report data from a cross-sectional survey including measures for socio-demographics, medical and substance use history, dental anxiety (MDAS), mood (CES-D), and oral health-related attitudes and behaviours; and (iii) visual examination caries data which was evaluated using the International Caries Detection and Assessment System (ICDAS) and converted to the decayed, missing filled (DMF) index. The oral health survey was completed in a non-probabilistic stratified sample of 298 prisoners, held in three Scottish prison establishments, representative of females, long-stay adult males, and male young offenders.

From the 31 literature articles included, there were indications dental caries experience may have been historically underestimated since early stage incipient caries lesions were not routinely captured. The evidence predominantly centered on known risk factors for other health conditions in this population e.g. socioeconomic status, patterns of health service utilization and substance use. There is little empirical evidence for how risk factors for caries vary between prisoner groups.

In the Scottish prisons surveyed, overall prevalence of total obvious decay experience (D_1MFT) was 97% and for caries into dentine (D_3MFT) was 96% with high proportions across all three populations. Mean scores were 12.89, 13.87, and 8.10 for D_1MFT, and 12.02, 13.28, and 6.20 for D_3MFT, among females, long-stay adult males, and male young offenders respectively. Age-adjusted multiple regression analysis determined intravenous drug use was a significant ($p < 0.05$) risk indicator for both D_1MFT and D_3MFT scores among females and adult males, whereas other risk indicators varied between the two populations. Number of cigarettes smoked per day

and dental attitudes also significantly explained both dental scores among females. For adult males, living in a non-stable living accommodation significantly explained higher D_1MFT scores, and for D_3MFT scores those whobrushed their teeth with fluoride toothpaste at home had significantly lower scores whereas those who had attended the prison dentist had significantly higher scores. Additional risk factors for adult males included: sugar consumption at home, length of homelessness, and prison dental attendance for D_1MFT; and length of homelessness and health condition(s) with shared common risk factors for D_3MFT. The findings for male young offenders indicate prison dental attendance, and dental anxiety may explain caries outcomes however, combined with marital status, these explained less than 10% of the variance in dental scores.

This thesis has shown dental caries experience in Scottish prisoners is highly prevalent and future programmes should be prioritised for prisoners known to have a history of substance misuse or at risk of developing such dependencies. This work has also highlighted the participants had experienced non-stable accommodations just prior to prison, and had experience of care and instability in their social relationships, suggesting the ‘causes of the causes’ of health inequalities are existent for the Scottish prisons population. Therefore, there is a need to address both upstream issues, such as policies and strategies to reverse social and economic factors which cause health inequities, together with global downstream programmes for the wider prisons population. These downstream health improvement programmes should adopt a common risk factor approach and incorporate smoking cessation and peer group interventions to address dental-health related attitudes among females, whereas for males greater emphasis on securing community-housing is needed alongside interactive and tailored oral health educational programmes.

1 Introduction

1.1 Overview

Dental caries remains one of the most common diseases worldwide [1-4] and, despite being a preventable disease with documented historical improvements, recent epidemiological surveys have reported reversed prevalence rates and increased caries among younger generations [5]. There are also demonstrable striking disparities where the most disadvantaged in our societies suffer the worst caries experience [6, 7] even where there are prevailing overall improvements [8]. Prisons settings are known for concentrating those vulnerable or from the lowest socioeconomic groups, and these populations often present to prison services with high and complex health care needs, including greater dental caries experience than general populations [7]. Whilst prison populations as a whole are disparate, there are also vulnerable sub-populations to be considered. For example, women prisoners, young offenders and older people, while they may have many of the same health problems as male prisoners, tend to have them to a significantly greater degree [9-11]. When developing oral health improvement strategies to meet the unmet dental needs it is therefore prudent to consider that risk factors for dental caries may, or may not, be experienced equally across all prisoners.

This thesis sought to develop evidence-based recommendations for effective oral health improvement programmes in the prison setting. The methodology was designed in reference to the Medical Research Council (MRC) recommendations for developing complex interventions [12]. A literature review was conducted to establish the empirical evidence for different experiences of dental caries experience and its related risk factors among prisoners. A study of three distinctive Scottish prisons was undertaken with female, long-stay adult male, and male young offender populations represented. The survey data were analysed to i) examine dental caries experience, ii) explore known and hypothesised risk indicators for caries, and iii) determine if a common risk factor model explained caries among all three populations or if tailored models were more appropriate.

1.2 Dental caries pathogenesis and disease stages

Human dentition is composed of four tissue layers with dental pulp forming the soft tissue in the centre and surrounding hard mineral tissues inclusive of dentine and enamel on coronal surfaces and cementum on the roots [13]. When exposed to organic acids the acid-soluble minerals are lost from enamel and dentine in a process termed 'demineralization', however the body has a natural repair mechanism, mainly supported by calcium and phosphate in the saliva, which can remineralize and thus repair the damage. Where demineralization exceeds remineralization over prolonged periods of time the dental tissue is effectively lost - the resulting disease is dental caries (decay) [14]. Dental caries is a progressive disease and over time, if conditions remain unfavourable, will result in the formation of cavities as shown in Figure 1.1 (images courtesy of the International Caries Detection and Assessment System [ICDAS] Foundation) [15].

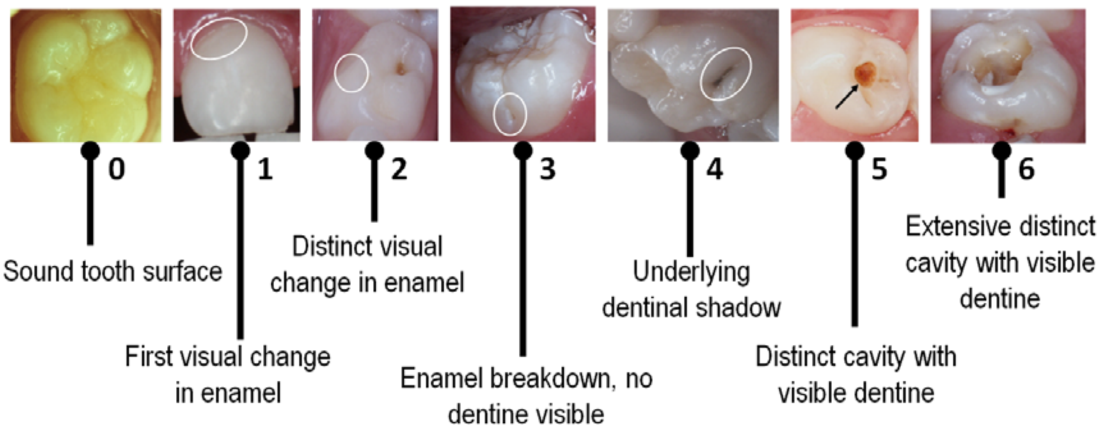

Figure 1.1 ICDAS coronal carious codes

As shown in Figure 1.1, caries becomes visually detectable when "white spot lesions" (also called 'incipient' lesions) appear on dried enamel; at the early stages (stages 1 and 2) the dentition can be repaired by making changes which promote an environment conducive for remineralisation. However, if demineralization continues the enamel layer becomes compromised (stage 3) to the extent that underlying dentine becomes exposed and the living tissues of the tooth become susceptible to damage and cavitation (stages 4-6).

The prevailing explanation for dental demineralisation is that proposed by Miller in the 1870s which extended our understanding beyond the work of Fauchard who first proposed sugars and acids were detrimental to the dentition [16]. Miller's investigations established the human mouth is host to multiple microorganisms and theorised the acids, produced by these resident microorganisms as a by-product of sugar fermentation, are the underlying cause of caries thus giving rise to the *chemo-parasitic caries theory* and establishing dental caries as an infectious disease [17]. This knowledge alongside the work of Keyes affirms our understanding that dental caries is an entirely preventable disease, in an otherwise healthy individual, where prevention in susceptible dentition is achieved by controlling the frequency of exposure to sugar and microorganisms [18]. Where dental caries does manifest, the resulting impact is wide-ranging affecting "*our ability to eat, the foods we choose, how we look, and the way we communicate*" (US Department of Health, 2000) [4].

1.3 Caries detection and assessment

With increasing emphasis on a preventive philosophy toward dental caries, recent advancements have been directed toward the measurement of pre-carious microbial activity [19] or technologies for the early detection of non-cavitated caries e.g. radiography, electrical conductivity, and auto-fluorescence [20]. Epidemiological investigations however require caries measures which are capable of quantifying prevalence across the disease spectrum since these investigations are primarily aimed at establishing the extent of the caries problem amongst populations [21]. In broad terms, the methodological strategies adopted to date can be grouped by i) detection of caries presence, ii) assessment of the caries activities, and iii) longitudinal monitoring of caries [19]. To ensure comparability between investigations, it is important to adopt quantification measures which are valid, reliable and reproducible. Sensitivity to the practical considerations faced by researchers and clinicians working in the field (feasibility) must also be carefully considered [22]. Visual-tactile examinations are the most frequently adopted methodologies amongst dental health cross-sectional epidemiological investigations perhaps, in part, owing to the acceptable cost implications, and their relatively non-invasive nature. Furthermore, this approach is particularly suited to the prison setting where high security mandates can preclude the use of technological equipment.

1.3.1 Caries diagnostic classification systems

There are numerous measures in use for the assessment of dental caries; since its introduction in the 1930s by Klein, Palmer and Knutson, the DMF index has prevailed as the most frequently adopted quantitative index in oral health population surveys worldwide [23]. As a cumulative lifetime measure of caries experience, the DMF index records the presence, and/or extent, of clinically detectable caries (decayed) lesions, restorative treatment received as a result of decay (filled), and extractions resulting from caries (missing) [18, 24]. At its introduction, the decayed sub-component of the DMF index was limited to the recording of cavitated caries; subsequent work, primarily published by the World Health Organization (WHO), introduced the concept of variable severity classification criteria often referenced as the D_1-D_4 criteria: [18]

- D_1 – clinically detectable but <u>intact</u> enamel lesions (i.e. non-cavitated)
- D_2 – clinically detectable and <u>cavitated</u> enamel lesions
- D_3 – clinically detectable cavities present and extend to dentine layer
- D_4 – caries lesions extend into the pulp

The introduction of wider thresholds does not however detract from a key limitation of the DMF index arising from its dichotomous scoring whereby caries is either scored as present or absent and therefore discrete disease severities are not distinguishable, for example adopting the D_1 criteria would result in scoring all caries, whether cavitated or not, as being present (i.e. D_2, D_3, and D_4 would be included but not individually distinguishable) [25-27]. Moreover, investigative reports will often not report the caries criteria adopted thus making comparisons impossible and limiting the conclusions that can be drawn from findings.

The International Caries Detection & Assessment System (ICDAS) is one validated measure of caries experience which was developed following a review of existing heterogeneous detection methods [28]. The ICDAS detection criteria are capable of detecting and assessing the severity of caries lesions, including early enamel lesions, whilst maintaining compatibility with the DMF index (see page 72) [19]. For these reasons adopting the ICDAS basic detection system presents a valuable opportunity to comprehensively investigate the caries experience in populations and the causal agents linked to all stages of the disease.

1.3.2 Prediction of caries incidence

Beyond the detection of frank caries, a comprehensive risk assessment will seek to determine the likelihood of caries incidence in the future. One method for independent assessment of future risk is caries activity status [29]. The principal underlying this approach is that active caries is an indicator that disease will progress further unless an intervention is put in place; moreover, whilst in an active state, the surrounding healthy dentition is also susceptible to disease. Conversely an inactive lesion indicates the caries process has stopped (arrested) or, in the early stages of disease, may be repaired over time. In practice, caries activity alone is not a comprehensive measure for prediction and a variety of disease markers should be considered including the number and location of caries lesions, plaque accumulation, dry mouth, and patient self-report data for known risk factors [13].

1.4 Policies for oral health improvement

In the UK, the role of sugars was borne out during the agricultural era when refined sugars introduced to the diet coincided with increased caries prevalence rates in particularly susceptible dentition e.g. pits, fissures and interproximal areas [17]. During the industrial revolution advancements in communications facilitated public health movements alongside pioneering technological advances, and environmental and economical changes, all of which contributed to health improvements over a range of outcomes. Examples of developments specific to oral health included dental therapies which allowed for treatment of manifest caries thus preventing the loss of teeth (dental mortality), dental health education to provide information to promote healthier individual behaviours e.g. toothbrushing and dental attendance, and health improvement strategies at the population level to introduce fluoride e.g. in toothpastes [17, 18].

The above health promotion strategies do not however explain all of the oral health improvements observed [30] and as described above, dental caries is a growing problem which is closely related to social gradients where individuals living and working conditions, alongside their lifestyles, influence their health outcomes which extend beyond oral health [31]. Oral ill health has been linked to general health [4, 32] and other disorders, illnesses and non-communicable diseases, including cardiovascular diseases [33, 34], respiratory diseases [35], cancer [36-38], premature birth [39-42], diabetes [43], HIV/AIDS [44], and osteoporosis [45, 46]. Thus dental health is not a distinct entity but rather is interconnected with a number of other health conditions [47] and the determinants of health are also multifaceted. The underlying 'causes of the causes' [48] including socio-economic, cultural and environmental differences [1, 4, 49, 50] influence and shape individual determinants, for example, behaviours such as dietary intake, smoking and alcohol [3]. An effective response toward improving health, including oral health, must therefore be planned and evaluated with sensitivity to the prevailing causal agents of these complex diseases. Furthermore, 'proportionate universalism' strategies are needed to ensure those individuals most in need or at risk are targeted [51].

Many of the health concerns and risk indicators noted above are common place in prisoner populations [11] and the burden placed on prison health services to address these are significant. As decreed in the Declaration of Human Rights [52], prisoners (and other vulnerable populations) have equal rights to health opportunities. Meeting the health needs of prisoners offers opportunities to our society which extend far beyond the health expenditure savings. The most recently revised recommendations of the United Nations General Assembly reaffirm minimum standards of care for prisoners founded on the principals of right to 'dignity and value as human beings', health, educational and employment opportunities, and cultural and social support, and further highlight the needs of vulnerable groups of prisoners [53]. In the US, the landmark case by Estelle v. Gamble (429 U.S. 97, 1976) upheld the same rights under the Eighth Amendment of the U.S. Constitution [54].

Couched within the principles of the Ottawa Charter for Health Promotion, 1986 [55] the development of increasing cohesive programmes for overall health and wellbeing have led to the development of common risk factor models. The common risk factor approach [47], recognises that risk factors for oral health and other non-communicable diseases can be addressed in cohesive programmes for overall health, including oral health improvement. In 2002, the World Health Organization World Health Report [56] acted as an impetus for change by identifying the need for a more holistic approach to oral health improvement and advocating the common risk factor approach for future health improvement projects. This was further supported in a later published WHO prison health report [57] where the unique challenges of working in prison dental services were acknowledged alongside the need for interventions which addressed the wider determinants of health in the prison setting. The WHO have also recognised "*Prevention and treatment responses must be based on scientific evidence and on sound public health principles*" (WHO, 2015) [3]. In Scotland, inequalities and ill experience have been recognised by the government and prisoners are identified as a vulnerable population with unmet dental health care needs [58]. The current health improvement prison policy in Scotland [59] advocates the 'whole prison' approach whereby programmes are designed to address health as a whole rather than specific disease experiences.

1.5 Prisoners

1.5.1 Population overview

Worldwide incarceration rates per 100,000 of the population have improved in some countries over recent years [60], however the total numbers still reflect a large population under the care of various prison administrations: in 2015 the World Prison Brief reported more than 2.2 million incarcerated in the United States alone, and 93,674 across the United Kingdom [61]. Prison settings are unique environments where these almost completely isolated communities, are also diverse, housing individuals of all ages, who are remanded or sentenced for a variety of criminal offences and who co-exist alongside the prison officers, management staff, and health care professionals charged with their care. Despite the diversity, disproportionately higher numbers of people from the lowest socioeconomic groups within societies are represented in the prison setting [57]. Concordant with this socio-demographic profile, prisoners will present with poorer physical and mental health experience when compared with the general population. The impact of poor health experience is also frequently felt much wider by the families of inmates and the communities they come from [62]. In one study of male young offenders, for example, higher caries experience was reported among those where a family member had been imprisoned [63].

1.5.2 Health experience

Despite long-standing policies to reduce health inequalities, prisoners are known to experience higher rates of illnesses, disorders or diseases when compared with the general population [11]. As described above, there are also vulnerable sub-populations within prisons to be considered [9-11]. The specific health needs are variable including minor ailments such as headaches or skin complaints as well as more severe physical and mental health conditions; often times multiple health conditions will require treatment [9-11]. A report of prisoners health in England determined half of prisoners were suffering with a mental health disorder including depression and anxiety; self-harm was not uncommon and suicide was estimated to be eight times higher among prisoners when compared with the general population [64]. Non-communicable health conditions such as cardiovascular disease and cancer have been linked to 'natural cause' deaths in custody [65]. Other health conditions included diabetes, respiratory disease, epilepsy, infectious diseases, digestive disorders, musculoskeletal problems, and dental health [64, 65]. The last national dental survey in Scottish Prisons, conducted in 2002, highlighted an extensive gap between the oral health of prisoners when compared with the general population with prisoners experiencing significantly greater experience of decay and three times greater experience of severe decay extending to the dental pulp [66]. Consequentially, the dental treatment needs of prisoners are high and indeed studies have shown that dental caries is one of the top reasons for presenting for treatment [67] and in the case of female prisoners is reportedly the top [68] or second most common [69] presenting symptom for treatment need.

1.5.3 Opportunities for oral health improvement

While it is acknowledged there is a need for upstream fiscal and policy changes necessary to address the "causes of the causes", or the social determinants of oral health inequality, it is also of value to consider more downstream strategies within a common risk factor agenda [48]. Addressing the oral health concerns of prisoners is beneficial on a number of levels: prisoners will engage with health services in the prison setting whereas in the community 'dental service utilization' tends to be neglected [70]; those who have a history of substance misuse/addiction outside of prison, are perhaps more likely to partake in detoxification programmes and thus more receptive to health education messages whilst inside prison; short-term sentences/remand holdings are frequently observed in the UK, thus prisoners who do gain health-related knowledge can impart this knowledge to the communities they return to outside of prison; prisoners often identify a healthy and white smile with better oral health related quality of life (OHRQoL) and improved employment opportunities [71].

Thus the prison environment presents opportunities for effective oral health improvement in what is otherwise a ‘hard to reach population’. Despite the benefits, there are challenges in meeting the dental health care needs of prisoners with high treatment requirements, limited resources and funding constraints [72]. The resulting impact on unmet oral health needs is acutely felt, for example in one article [73] prisoners expressions of “*missing mouths*” were reported, where prisoners, in severe pain and struggling to self-medicate, experienced difficulties eating, and feared unnecessary tooth extractions and the resultant impact on self-esteem [70, 73]. To ensure future programmes are effective in addressing the oral health needs of prisoners it is important to understand the prevailing risks factors for disease experience.

1.6 Statement of the Problem

Whilst global rates of dental caries have improved, epidemiological surveys have demonstrated this preventable disease persists disproportionately in areas of greatest social deprivation [31]. High lifetime caries experience in prisoners has been well documented [74] and there are numerous policies which identify this vulnerable population as a priority group for dental health programmes. Moreover, whilst prison populations as a whole are disparate, there are also vulnerable sub-populations to be considered for example women prisoners [66], young offenders and older people [10]. Prisoners are therefore an important population for consideration when developing personalized oral health improvement programmes. Improving our understanding of prisoners’ caries experience, including severity of disease and the associated risk indicators is an important step in ensuring individual dental health needs are promptly identified and effectively addressed.

1.7 Research aims and objectives

This thesis sought to assess how dental caries and its related risk indicators vary between vulnerable prison populations with a view to make recommendations for evidence-based tailored oral health improvement programmes. The specific objectives were to:

1. Conduct a comprehensive review of prisoners dental caries experience and its related risk indicators
2. Provide empirical evidence of dental caries prevalence and severity experienced by the prison population of Scotland using data from a cross-sectional survey, conducted in 2011, which specifically included women, youth offenders, and long stay male prisoners
3. Explore the prevalence of potential and hypothesised risk indicators for caries and test for associations with caries cross-sectionally in the population of study
4. Build explanatory models for total caries experience and severe caries experience and determine if the data support different risk indicator experiences in the sub-populations studied
5. Make recommendations for oral health improvement policy in prison settings.

1.8 Research methods

The findings reported include a comprehensive literature review and empirical data from a cross-sectional dental health survey conducted in three Scottish prisons representative of female, long-stay adult male, and male young offender populations. The survey was designed to inform an oral health needs assessment which in turn would be used to develop personalised complex interventions for prisoners, thus data collected was suited to the stated aims and objectives of this thesis.

The dental survey data included (i) normative need based on lesion detection and assessment [75] using the ICDAS coding system [19], and (ii) prisoners' self-report questionnaire data for a range of potential risk indicators including utilization of dental services, psychosocial health, substance use, and socio-demographic, economic and medical impacts. All dental examinations were performed by trained dentists; no radiographs were taken and no assessment of dry mouth or caries activity was made.

As experienced by other researchers [76], analysing the extensive ICDAS data generated in a meaningful way was one of the challenges of this thesis. The descriptive findings include summaries of the ICDAS lesion assessment data, however to facilitate statistical analysis the ICDAS data were converted to the DMF index. The two caries classification systems are overviewed in section 1.3 and the conversion from ICDAS to DMF is detailed in the study methods (section 3.8.2). In brief, tooth level experiences of decayed, missing or filled dentition (DMFT) are reported and where a tooth was both decayed and filled it was considered decayed. The analysis was restricted to 28 teeth (excluding third molars) and to two severities: total obvious decay experience (D_1MFT) and caries into dentine (D_3MFT). Table 1.1 summarizes the nomenclature adopted; D_4 was additionally calculated to permit comparisons with historical studies of caries experience amongst prisoners.

Table 1.1 Nomenclature for ICDAS to DMF conversion

Description	ICDAS caries codes	DMF D-component
Total (obvious) decay experience	1-6	D_1
Caries into dentine	4-6	D_3
Severe decay (extending into dental pulp)	5-6	D_4

My contributions in this thesis, outside of authoring, included developing the research aims and objectives, and, for the literature review to, (i) development of the methodology, (ii) perform searches and data extraction, (iii) critically appraise included studies (iv) document the findings and (v) write the results and discussion. For the SOHIPP survey my contributions included (i) working with investigators to ensure compliance with governance requirements with specific responsibility to liaise with the National Health Service (NHS) ethical and research and development boards and the Scottish Prison Service (SPS) ethics committee (ii) to monitor adherence with study protocol, (iii) to liaise with NHS Education for Scotland to finalize the design of the data collection form and coordinate scanning of completed forms, (iv) to coordinate with stakeholders including prison healthcare management, the examining dentists, and ICDAS trainer, (v) to arrange strategic and operational meetings and a training session, (vi) to prepare participation packs and arrange survey visits, (vii) to carry out data collection including scribing the dental charts and, where needed, supporting participants to complete the self-report section, (viii) data entry (dental charts) and prepare the statistical database for study analysis e.g. checking outliers against original forms, calculating summary scores, (ix) to write the SPSS syntax to compute the DMF scores, (x) coordinate with the statistician to detail an analysis plan for this thesis, (xi) perform the analysis, (xii) interpret the findings and (xiii) write the results and discussion.

1.9 Thesis structure

The thesis overall consists of six chapters. This introductory chapter presents the background and populations of interest, and the aims and objectives are stated above.

Chapter 2 presents a synthesis and quality assessment of the current evidence base for dental caries experience among prisoner populations, and an exploration of the reported determinants of dental caries experience.

Chapter 3 reports the methodology for the 2011 cross-sectional survey of Scottish prisoners which forms the basis of the thesis. The self-report potential risk indicators for caries and the dental examination procedures are described alongside the statistical methods.

Chapter 4 reports the main findings for all potential risk indicators and their association with the caries outcomes of interest and the final dental caries explanatory models for each of the three prisoner populations. Chapter 4 begins with an introduction (section 4.1) and description of the sampled sub-populations (females, long-stay adult males, male young offenders) including response rates, consent to examination and sample representativeness (section 4.2); the remaining results are reported in three parts:

- Part 1: descriptive results for each of the risk indicators measured (known and hypothesized) and the prevalence and severity of caries experience.
- Part 2: associations between each risk indicator and the two caries outcomes: total obvious decay (D_1MFT) and caries into dentine (D_3MFT).

- Part 3: final multivariable explanatory models for each caries outcome and for the whole study population, and each of the three surveyed prisoner populations.

Chapter 5 is the discussion of the study results within the context of the wider literature.

Chapter 6 reports on the conclusions and gives recommendations for how the caries risk indicators and models can inform future policies to improve dental health care for prisoners.

2 Literature review

2.1 Aim and scope

Couched within the principles of the Medical Research Council Framework for Complex Interventions [12], a comprehensive narrative review of the literature is presented in this chapter. The review adopted a systematic approach with the aim to identify the prevalence and severity of caries experience in prisoner populations in addition to the associated risk and/or protective factors for caries experience.

2.2 Review methods

2.2.1 Data sources

The search terms were comprised of subject headings e.g. medical subject headings (MeSH), and keywords. The terms included were designed for *specificity* in terms of the population (prisoners) or setting (prisons), and outcome of interest (dental caries); to ensure *sensitivity* for the articles of interest, the criteria were not restricted to severity of dental caries. All searches (see Appendix 9.1) were performed during December 2012 using 6 electronic databases: MEDLINE (EBSCOhost®), Embase (OvidSP), Cinahl Plus (EBSCOhost®), SCOPUS (SciVerse), PsychARTICLES (APA PsycNET®), and Applied Social Sciences Index and Abstracts [ASSIA] (ProQuest). Searches were repeated in August 2015 with limits applied to the publication dates in order to identify newly published articles.

The electronic database searches described above were supplemented by hand searches of the referenced articles (where a full text was obtained) and a further targeted search, in a dedicated database generated and held by the Oral Health and Health Research Programme Group, Dental Health Services Research Unit, University of Dundee. The latter database was a collaboration with Dr. Markus Themessl-Huber, Professor Ruth Freeman, and Dr. Steve MacGillivray (University of Dundee).

2.2.2 Eligibility criteria

Articles, irrespective of publication year, were screened for eligibility against the following criteria:

I) Inclusion criteria:

- Reported population of prisoners: defined as individual(s) suspected or convicted of committing a crime subject to court proceedings and detained in detention facility or under house arrest/electronic tagging;
- Primary outcomes of interest empirically identified: prevalence or severity of decayed dentition;
- Reported risk or protective indicators where dependent variable/attribute was caries experience.

II) Exclusion criteria:

- Reported institutionalized populations not subject to criminal court proceedings e.g. prisoners of war; refugees; psychiatric patients;
- Reported only aggregate dental caries experience (e.g. DMFT) i.e. without specifying decayed dentition (e.g. DT);
- Not in english language.

2.2.3 Article screening

All titles and abstracts identified from the initial literature search were exported to Endnote version X5 (© Thomson Reuters) and screened by two individuals (TA; RF) based on the above inclusion/exclusion criteria. The PRISMA Flowchart [77] was used to structure the assessment process whereby the abstract (or title where not obtainable) was initially screened and subsequently a full-text was sought for all eligible articles. The full-texts were subsequently screened using the same criteria (see 'Eligibility criteria' above).

2.2.4 Data abstraction

2.2.4.1 Quality assessment

To standardise the quality assessment process, the Fowkes and Fulton (1991) checklist [78] was adopted however modified to include one additional domain to assess bias due to funding or conflicts of interest [79]. Thus the strengths and limitations of each included article were abstracted using a standard form with a total of 7 domains (listed below), and each domain was assessed and scored as 'low', 'medium' or 'high' (where 'high' represented greatest risk of bias).

- Appropriateness of study design;
- Representativeness of study sample *e.g. recruitment strategy including prisons visited, inclusion/exclusion criteria, refusals reported*;
- Acceptability of control group (where applicable) *e.g. validity of caries comparisons [for example comparable methods], confounding [for example age, gender, geographical], interval between surveys*;
- Quality of measures and outcomes *e.g. caries assessment criteria, standardization incl. examiner training or calibration, data entry verification*;
- Data completeness *e.g. missing data and missing data handling, exact p –values*;
- Distorting influences *e.g. confounding and statistical methods employed, extraneous prison factors which may have influenced recruitment or examination*;
- Funder and/or author biases: *limited to whether statement for each given, although it is acknowledged not all publishers print this information*.

2.2.4.2 Caries experience

Data were abstracted for: prevalence and severity of decayed dentition, caries experience (decayed, missing, and/or filled), methods for assessing caries experience, risk or protective factors for caries experience. Where an article did not provide numerical values for the total study population, the group numbers were used to calculate the populations' mean value. The level of unmet caries treatment need was assessed by calculating two indices: percentage (%) D/DMFT which represents unmet treatment need as a proportion of lifetime caries experience and secondly, %D/DFT which represents unmet caries experience as a proportion of restorative needs.

2.3 Review results

2.3.1 Articles selected

The 2012 electronic search generated 638 citations of which 159 were duplicates. Where possible (314), both title and abstracts were screened according to the inclusion/exclusion criteria, although for 147 articles only the title was available for screening. A review of the 'Oral Health in Prisons' electronic database (DHSRU, University of Dundee) generated six further articles. A manual search of the included articles identified an additional five articles.

In total 101 articles were deemed suitable for full-text review however 22 texts were un-retrievable. A further 53 articles were excluded with a reason. Reasons for exclusion included: no prisoner population identified; no dental caries outcomes reported (e.g. policy; forensic odontology; periodontal research); descriptive articles (e.g. dental services or extramural programmes); and no discernible account of decayed dentition. Two reviews by Treadwell *et al.* and Walsh *et al*. were also excluded [74, 80] as they did not provide original study findings for caries experience. Thus in total 26 articles [66, 81-105] were included in 2012.

The articles from the 2015 'updated' searches were screened separately for eligibility. Five additional articles of relevance were identified with publication years 2013 and 2014 [71, 106-109].

A summary of the assessment process is depicted in the PRISMA flow diagram (see Figure 2.1).

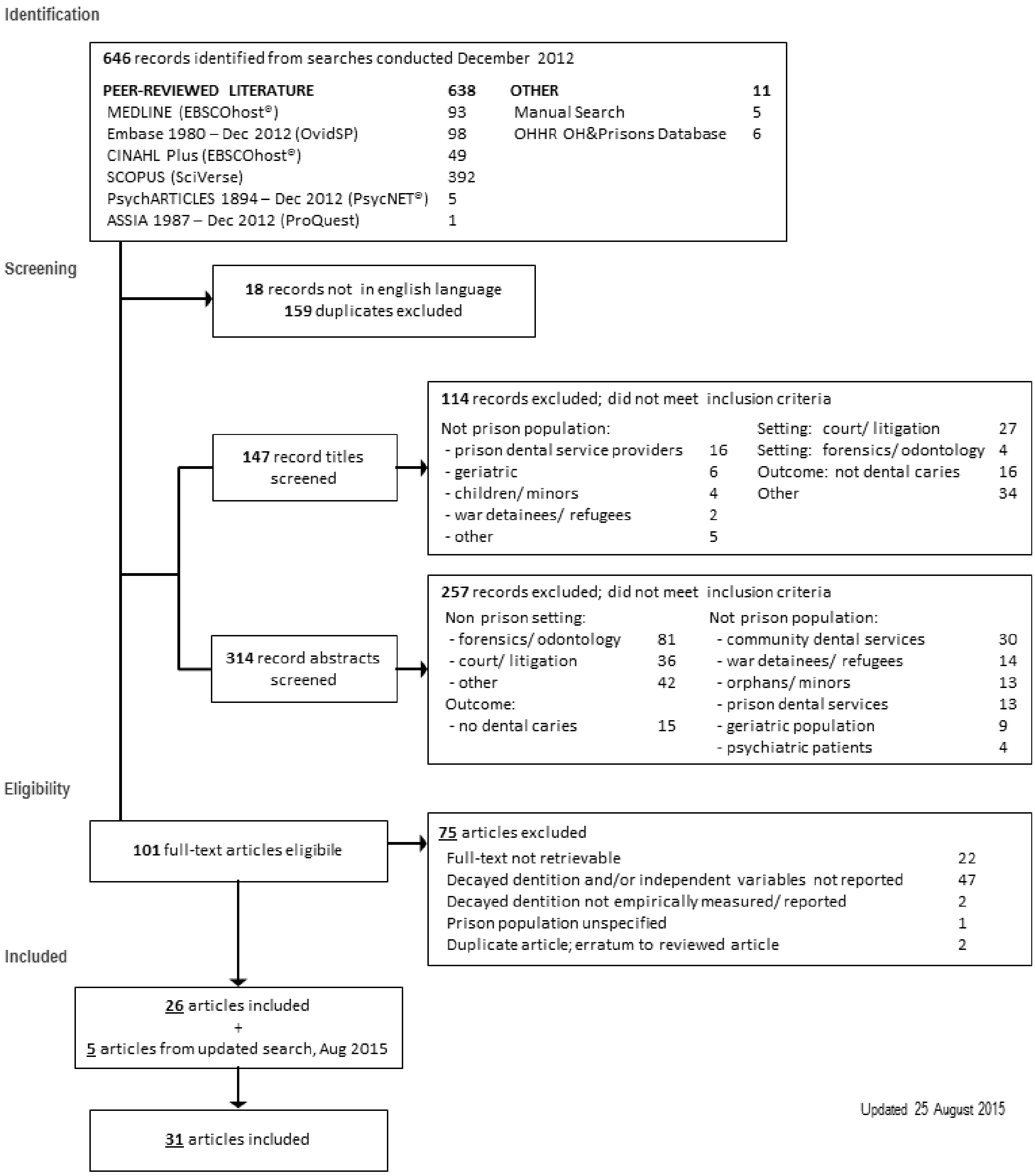

Figure 2.1 Flowchart of article assessment process

2.3.2 Number of unique studies

Two articles [93, 94] reported the findings of a single study conducted in England; and two further articles [85, 86] referred to a study with two time points. The two, first author, Shapiro articles [104, 105] were verified as distinct studies. Similarly, the two articles with principle author Heng [95, 96] were unique studies with distinct data collection phases and the first author Jones articles [66, 98] describe data collected from different geographical areas (England, Scotland). Thus the 31 included articles were representative of 29 individual studies (Table 2.1).

Table 2.1 Geographical coverage of studies examining caries experience in prisoner populations

Country	Region / State	No of Studies	Publication Year
France [82, 91]	Lille	1	1997
	Puy-de-Dôme	1	2012
Italy [100]	Calabria	1	2007
Norway [97]	Southern Norway	1	1984
UK [66, 93, 94, 98, 99, 107, 108]	England	5	2003, 2005, 2007*, 2008*, 2013, 2014
	Scotland	1	2004
US [81, 83-90, 92, 95, 96, 101-105]	California	1	1972
	Connecticut	2	2002, 2006
	District of Columbia	1	1970
	Iowa	2	1985, 2002
	Maryland	2	1969, 1989
	Massachusetts	1	1973
	Michigan	2	1977, 1997
	Mississippi	1	2006
	New York	1	1994
	North Carolina	1	1998**, 2002**
	Texas	2	1972, 2006
Brazil [71, 109]	Paraná	1	2014
	Paraíba	1	2014
Australia [106]	New South Wales	1	2014

* Same study population published in multiple articles; ** Baseline and follow-up articles

2.3.3 Historical and geographical coverage

Publication dates ranged from 1969 to 2014. A peak was observed in the period 2000-2009 during which 12 articles were published (six from US [83, 84, 86, 89, 95, 96]; five from the UK [66, 93, 94, 98, 99] and one from Italy [100]). In total, seven countries worldwide were identified with a number of regions/states represented (Table 2.1). Whilst a large number of articles (18) originated from the US the most recent of these were dated 2006.

2.3.4 Study sampling frames

The descriptors used for the populations available for study were mixed although, broadly speaking, could be categorized as *setting, security level,* or *population* classifications (see Table 2.2).

Table 2.2 Sampled prisoner populations represented in caries literature

Descriptors for sampled populations	
Setting	Detention center, state , federal, county, correctional, Socioeducation Center, juvenile justice centre, juvenile custodial centre, reception center, penal institution house, remand home, prison unit
Security	Low, high, minimum, medium, maximum, administratively segregated, 'close'
Population	Juvenile, girls, boys, adolescents, young offender, adults, female, male
Offences	Remand, convicted, 'drug-related offences', 'property offences'

The incarceration periods observed in these facilities were reported in a number of studies however the varied format meant only five articles could be directly compared since they consistently reported the mean sentence period or average incarceration length in years or days [81, 83, 95, 100, 109]. Other examples were general descriptions such as 'short' or 'long' term [89, 97, 102, 103, 105]. Similarly, when comparing the population sizes, variable descriptors included: "capacity of holding facilities" [94, 96, 99, 102, 103], "average daily population" [82, 87, 88], "annual population" [81], "census during the study period" [66, 91, 100, 101], "monthly census" [83], "admissions per day" [94], or "admissions per year" [99].

2.3.5 Study designs

Most of the included studies were observational and cross-sectional in nature with two reportedly sampling the entire prisoner population in the establishments visited [104, 105] (see Table 2.3). One retrospective routine data-based study was determined [52] and one author used a mixed methods approach whereby retrospective dental charts performed within the previous year were combined with clinical examination data [101]. A single case-control study was determined whereby a comparison was made between ‘heroin addicts’ and ‘non-addicts’ [82]. One study presented the oral health findings in a cross-sectional survey and subsequently reported prospective findings from a follow-up survey performed post-intervention [85, 86].

2.3.6 Study populations

Whilst both genders were represented in the examined populations, there were more males [71, 90-94, 97, 100-103, 107, 109] when compared with females [81, 95, 96, 104, 105, 108]. When combined the number of male participants were five times (n = 8798) that of females (n = 1819) across the articles. The youngest mean age reported was 15.35 years pertaining to a study of both male and female juvenile detainees [83]; the oldest mean age of 39 years was for a study of male prisoners [91, 100]. The relative poorer representation of female young offenders was evident with only one additional study of young offenders including a small number (n = 26) of females [106].

2.3.7 *Dental caries experience*

The number of oral examinations performed varied from 59 [105] to 1,971 [85]. Almost ubiquitously, the studies assessed point prevalence of caries. See Table 2.4 for the data extracted for DMFT index and/or its sub-components and Table 2.5 for studies reporting other caries indices. As detailed in the quality assessment section (page 50) the caries assessment criteria adopted varied across the studies thus direct comparisons were not feasible.

The data for lifetime caries assessed as decayed, missing and filled teeth (DMFT) was dated between 1969 and 2014 (23 studies in total). There is a lot of variability over the timeframe (Figure 2.2) although higher rates were observed in the earliest studies published in the 1970's and early 1980's – perhaps indicative of an improvement over time [92, 97, 104, 105].

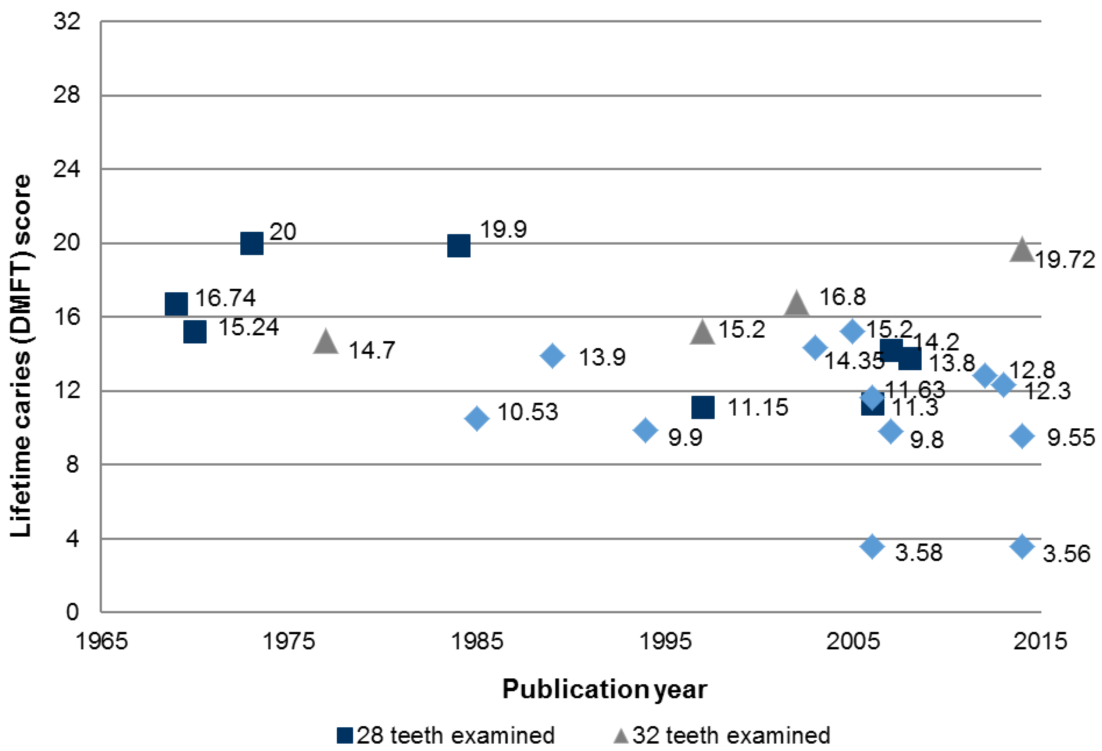

Figure 2.2 Lifetime caries experience over time reported in the literature

Mean number of decayed teeth (DT) also varied between studies, ranging between 1.9, in a study of young offenders aged between 12 and 17 years of age, [83] and 11.06 in a population of male prisoners in Brazil aged between 18 and 55 years of age [71].

Similar differences were observed for the five studies reporting decayed surfaces (range DS, 3.6-15.1) [84-86, 96, 100]. Due to variability in study populations, settings and methods for caries detection (see Table 2.3), a meta-analysis was not feasible. A detailed descriptive analysis was restricted nevertheless, some general trends were observable from the data available.

An examination of the proportion of unmet caries treatment needs (expressed as decayed teeth as a percentage of lifetime caries experience [%DT/DMFT]), determined older study populations had lower proportions of unmet need (based on data from 18 studies) – this trend persisted in both male and female population studies. However, whilst unmet need decreased, the proportion of missing teeth increased, whereas restorations were variable and typically lower than the missing component at older ages (see Figure 2.3); this is suggestive that carious teeth were extracted rather than restored.

Figure 2.3 Literature reports of decayed, missing and filled teeth in prisoners

In consideration of the severity of caries, only one study [67] distinguished data for early enamel lesions (comparable to ICDAS 1 and 2) – these were identified in their 'low' treatment urgency group which included incipient disease. However, the data were based on retrospective (routine) chart review and therefore the experience of such early lesions is likely underestimated since they are not always routinely recorded. No other study distinguished early enamel lesions from cavitated caries experience.

A single article reported caries grouped as 'decayed teeth' or 'severely decayed teeth' [66] where the latter category was equivalent to D_4 (caries extending to the dental pulp). Jones *et al.* (as was the case with many other studies) did not define or describe the detection criteria for 'decayed teeth'. In this report and two additional studies, [93, 94, 98] the 1998 UK Adult Dental Health Survey (UKADHS) method was referenced and an independent follow-up of the UKADHS source article determined a tooth was considered 'decayed' at a threshold where visual caries could be detected including demineralization without cavitation [110]. This is consistent with D_1 or either ICDAS stage 1 or 2 threshold for early enamel lesions. In other published studies the diagnostic criteria for coronal dentition were variable.

The 2009 UKADHS method [108] adopted in one study recorded caries as present where the dentine was compromised including non-cavitated caries where a dentinal shadow was evident [111]. This caries threshold is comparable to D_3 or ICDAS stage 4 (non-cavitated lesions). Similarly, the World Health Organization (WHO) Oral health surveys: basic methods, first and 4th editions were referenced in a number of studies [71, 97, 100, 102, 106, 109]. Here the threshold for caries was evidence of cavitation or destruction to the underlying dentine. Boyer *et al.* and Gilmore and Gluck both described their criteria for caries assessment [84, 92]. The specifications allowed for dentition to be considered as decayed if caries extended to the dentine; thus the criteria were determined to be comparable to a threshold of D_3 or ICDAS stage 4 as well.

The National Institute of Dental Research (NIDR) method in its original form [112] assessed frank cavitated caries in addition to non-cavitated caries that could be detected (visually or with the aid of a probe) i.e. where demineralization had occurred leading to destruction of enamel. For this study, the results were comparable to D_1 or ICDAS stage 3. In another study [84] the NIDR criteria was modified to exclude early enamel lesions, thus the results were equivalent to D_2 or ICDAS 4 thresholds. The Klein & Palmer criteria referenced in one study [82] was based on a method which excludes incipient caries lesions [113]; the criteria were therefore likely equivalent to D_2 or ICDAS 3 thresholds. Finally, the Radike criteria were cited by a single study [96] however it was not possible to determine a source article for a description of the detection thresholds.

In summary the literature for coronal caries experience in prisoners is more representative of cavitated caries extending to the dentine. Many of the methods adopted were chosen for their compatibility with other population based surveys.

Beyond the consideration of caries detection methods, a second aim of this review was to ascertain the determinants for caries experience reported for the prison populations studied. The risk and protective factors for decayed dentition and/or total obvious decay experience were abstracted and the findings are reported in the next section.

Table 2.3 Methodological approaches for determining dental caries reported in the literature, *n* = 31

First author [Ref#]	Data collection phase / duration	Study design	Country	Prison sites (N)	Exclusion criteria	Dental examiner(s), recorder(s)	Caries diagnostic criteria	Data collection instruments	Radiographs used	Caries outcome measure(s) reported	Teeth examined (N)
Badner [81]	4mths	CS	US	1	None	*n* = 1; experienced and calibrated	ND	Location: examination room; standard dental screening report form; structured interview	ND	DMFT	ND
Becart [82]	ND	CC	France	1	Edentate; > 35 years of age	ND	Klein & Palmer, 1946	Standard form; mirror; explorer; adequate illumination	No	DMFT	28
Bolin [83]	Sep 1999-Dec 2003	Retrospective chart review	US	1	Not 12-17 years of age; not examined by same dentist	*n* = 1 dentist	Association of State and Territorial Dental Directors (ASTDD) manual of Assessing Oral Health Needs	ND	ND	DMFT	ND
Boyer [84]	Jun-Dec 1998	CS	US	1	None reported	*n* = 1 dental hygienist	Amended National Institute of Dental and Craniofacial Research criteria; Incipient lesions, not into dentine, not included as caries;	Routine standardized exam chart; mouth mirrors; explorers	Yes: panoramic	DMT; DS	28/ 32

First author [Ref#]	Data collection phase / duration	Study design	Country	Prison sites (N)	Exclusion criteria	Dental examiner(s), recorder(s)	Caries diagnostic criteria	Data collection instruments	Radiographs used	Caries outcome measure(s) reported	Teeth examined (N)
Cavalcanti [71]	ND	CS	Brazil	1	Disciplinary isolation; affected by infectious diseases; history of head & neck radiation therapy or Sjorgren's syndrome, other exocrine disorder	Examiner: *n* = 1 calibrated; Recorder *n* = 1 trained; Kappa=0.92	Instrument based on WHO methods – edition not specified	Data collection instrument (Brazilian Oral Health Survey); Interview; clinical examination; aprons; disposable wooden spatulas; gauze; mouth mirrors, sterilized millimeter probes (CPI)	ND	DMFT	32
Clare [85]***	1996/ 8 consecutive weeks	CS: baseline	US	6	None reported	*n* = ND: trained dentists	ND	Standard survey sheet; mirror; explorer	No	DFS; Caries Control Procedure (CCP)	ND
Clare [86]***	ND	CS: prospective follow-up	US	ND	Not continuously in prison since BL	ND	ND	Survey form	ND	DFS	ND
Colon [87]	4.5 years	CS	US	1	ND	ND	ND	ND	Yes	DMFT	ND
Colon [88]	July 1968-Feb 1970 / 18mths	CS	US	1	Edentulous; Minority ethnicities: Puerto Rican, South American, Central American and Canadian	*n* = 1 dentist	ND	ND	No	DMFT	32
Cropsey [89]	ND	CS	US	ND	None	*n* = 2 trained and calibrated dentists	ND	Depending on literacy, interview or paper-pencil instrument	ND	DMFT	ND
Cunningham [90]	Jan to March 1980 / 2.25mths	CS	US	1	None	*N* = 1	ND	ND	ND	DMFT	ND
Decerle [91]	Dec 2006-Jan 2007	CS	France	3	None	*n* = 1 calibrated	ND	Semi-guided interview; clinical dental examination	ND	DMFT	ND

First author [Ref#]	Data collection phase / duration	Study design	Country	Prison sites (N)	Exclusion criteria	Dental examiner(s), recorder(s)	Caries diagnostic criteria	Data collection instruments	Radiographs used	Caries outcome measure(s) reported	Teeth examined (N)
Gilmore [92]	ND	CS	US	2	Edentate*	*n* = 3	Standardised method	Questionnaire; location: dental clinics; mirror; explorer	ND	DMFT	28
Haysom [106]	Aug-Oct 2009	CS	Australia	9	Work and court commitments	*n* = 1 oral health therapist	WHO, 1997	Face-to-face questionnaire; dental exam: 'standard equipment'	ND	DMFT; D/DMFT	ND
Heidari [93, 94]	Oct 2004-Mar 2005	CS	UK	1	None	Examiner: *n* = 1 experienced dentist; Recorder: calibrated senior dental nurse	1998 Adult Dental Health Study (modified to exclude third molars)	Questionnaire administered as structured interview (literacy); dental exam	No	DMFT	28
Heng [95]	Feb 14th-Apr 25th 2001 / 2.39mths	CS	US	1	*n* = 3 excluded: smoking status not provided	*n* = 1 calibrated examiner	National Institute of Dental and Craniofacial Research (NIDCR)	ND	No	DMFT	28
Heng [96]	31 May 1997 - 21 May 1998 / 11.75mths	CS	US	1	None	*n* = 1 trained dentist	Radike criteria; Missing (M) included reasons other than caries	Mirror; explorer; 'ideal lighting'	Yes: 4 intraoral bitewing	DMFS; DMFT	32
Hurlen [97]	11mths	CS	Norway	1	Ethnicity (*n* = 1)	ND	WHO,1971	Semi-structured interviews	ND	DMFT	28

First author [Ref#]	Data collection phase / duration	Study design	Country	Prison sites (N)	Exclusion criteria	Dental examiner(s), recorder(s)	Caries diagnostic criteria	Data collection instruments	Radiographs used	Caries outcome measure(s) reported	Teeth examined (N)
Jones [66]	Apr-May 2002 / 1mth	CS	UK	7	Edentate	*n* = 3 dental examiners: experienced and calibrated; two recorders per dentist	United Kingdom Adult Dental Health Survey (UKADHS), 1998	Purpose-built lamp (described); No. 4 plane mouth mirrors; straight probes (blunted to 0.3 mm diameter); rubber gloves; cotton buds/ sterile wipes; yellow waste disposal bags; extension lead & circuit breaker	No	DFT	ND
Jones [98]	Nov-Dec 2000	CS	UK	16	Edentate	*n* = 3 trained and calibrated dentists	UKADHS, 1998	Interview; dental examination	ND	DMFT	ND
Lunn [99]	March to June 2001	CS	UK	1	None	*n* = 1: salaried dentist	Routine clinical data	ND	Yes, as required	DMFT; extraction required	ND
Marshman [107]	ND	CS	UK	3	Female; not 20-35 years of age	Trained, calibrated examiners	ND	Structured interviews; oral examinations	ND	DT	ND
Martins [109]	Jul-Dec 2011	CS	Brazil	1	Pilot results	*n* = 1 calibrated investigator	Manual for Calibration of Examiners of Projeto SB Brasil 2010: based on WHO 4th edition, 1999	Dental chai; artificial light; mouth mirror; ball point periodontal probe; clinical form	ND	DMFT	ND
Nobile [100]	Feb-Jun 2005	CS	Italy	4	None	*n* = 1: trained and calibrated	WHO, 1997 [coronal caries]; Banting et al. [root caries]	Structured interview; location: 'regular dental room'; artificial light; plane mouth mirror; explorer; periodontal ball-pointed probe	No	DMFT, DMFS; Root caries	ND

First author [Ref#]	Data collection phase / duration	Study design	Country	Prison sites (N)	Exclusion criteria	Dental examiner(s), recorder(s)	Caries diagnostic criteria	Data collection instruments	Radiographs used	Caries outcome measure(s) reported	Teeth examined (N)
Ormes [101]	ND	CS: mixed methods	US	13	Records > 1 year old	ND	Existing dental records; routine exam	Mirrors; explorers; reflected light; periodontal explorers	Yes	DMFT	32
Ross [102]	ND	CS	US	1	> 34 years of age; *n* = 1 couldn't be assessed due to severe decay	Examiner: *n* = 1 public health dental hygienist; Recorder: trained inmate	WHO 1971**; two 'related studies' (referenced);	Location: dental clinic with dental chair; artificial light; sickle type explorers; mouth mirrors; periodontal probes	ND	DMFT	32
Rouxel [108]	Jul-Aug 2010	CS	UK	1	Prisoners mother and baby unit; Non-english speaking	*n* = 1 trained, calibrated dentist; dental nurse recorded data	2009 ADHS	Interview; clinical examination	ND	DMFT; PUFA index	ND
Salive [103]	Oct 1987 - Feb 1, 1988	CS	US	1	None	*n* = 1 dentist: calibrated	'Visible occlusal and interproximal caries'	Standard form; mouth mirrors; #5 Shepherd hook explorers	Yes: panoramic	DMFT	ND
Shapiro [104]	Oct 1 to Dec 31, 1969 / 3mths	CS: whole prison survey	US	1	None	Examiner: ND; Recorders: two inmates employed & trained as dental assistants	Field Investigation Branch of National Institute of Dental Research (NIDR)	Standard NIDR form; mirror; explorer; adequate illumination	No	DMFT	28
Shapiro [105]	March 1970 / 1mth	CS: whole prison survey	US	1	None for caries examination	ND	Field conditions	Standard NIDR form; mirror; explorer; adequate illumination	No	DMFT	28

* Excluded from analyses; ** citation numbering error in article; *** Baseline and follow-up studies; CS=cross sectional; CC=case-control; NA=not applicable; ND=information not disclosed; CPI=Community Periodontal Index; NOVA=analysis of variance; ANCOVA=one-way analysis of covariance

Table 2.4 Published reports of caries experience in prisoner populations: DMFT index

First author [Ref#]	Year	Unit of variance	Total exams	Edentate (N)	Gender (N)	$\bar{X}$ age (range), years	Lifetime caries, DMFT	Decayed teeth (DT)	Missing teeth (MT)	Percentage D/DMFT (%)	Percentage D/DFT(%)
Number of teeth examined not reported											
Badner [81]	1994	ND	183	ND	Female (183)	27.6 (20-39)	9.9	2.37	3.50	23.9	34.3
Bolin [83]	2006	*SE*/*SD*	419	ND	Female (103); Male (316)	15.35 (12-17)	3.58 (*SE* 0.17; *SD* 3.39)	1.9	0.06	53.1	54.3
Colon [87]	1972	ND	102	ND	Female (20); Male (82)	(18-44)	*	*	*	*	*
Cropsey [89]	2006	*SE*	1,275	ND	Male (1,174); Female (101)	29.4 (18-69)	11.63	4.35	4.76	37.38	65.59
Cunningham [90]	1985	*SD*	99	ND	Male	(18-30)	10.53 (5.97)	3.07 (3.75)	1.76 (2.90)	29.15	35.05
Decerle [91]	2012	*SD*	84	ND	Male	39	12.8 (7.8)	2.4 (3.4)	6.3 (7.1)	18.7	36.9
Haysom [106]	2014	*SD*	294	ND	Male (268); Female (26)	(13-21)	3.56 (3.62)	1.92	*	54	*
Jones [66]	2004	ND	530	26 - excluded	Male (424); Female (106)	31.4 (16-71) **	*	2.56	*	*	36.00
Jones [98]	2005	*SD*	272	6 - excluded	Males (188); Females (84)	ND	15.2	4.7	6.4	30.9	53.4
Lunn [99]	2003	*SE*	126	ND- included	ND	ND	14.35 (0.68)	3.80 (0.31)	6.32 (0.53)	26.5	47
Marshman [107]	2014	*SD*	659	ND	Male	28.9	ND	2.87 (4.0)	*	*	*
Martins [109]	2014	*SD*	107	ND	Male	16.5 (13-19)	9.55 (5.17)	7.43 (4.80)	0.49 (1.08)	77.8	82.0
Nobile [100]	2007	*SD*	544	7 (1.3%)	Male	38.7 (20-81)	9.8 (6.1)	2.3 (2.5)	6 (5.9)	23.5	60.5
Rouxel [108]	2013	*SD*	103	0	Female	30.9	12.30 (7.48)	2.47 (2.52)	4.96 (4.92)	20.08	33.65
Salive [103]	1989	*SD*	178	2 - included	Male (178)	30.8 (18-45+)	13.9	2.7	6.4	19.4	36.0

First author [Ref#]	Year	Unit of variance	Total exams	Edentate (N)	Gender (N)	$\bar{X}$ age (range), years	Lifetime caries, DMFT	Decayed teeth (DT)	Missing teeth (MT)	Percentage D/DMFT (%)	Percentage D/DFT(%)
28 teeth examined											
Becart [82]	1997	*SD*	93	0 - excluded	Male (69); Female (24);	25 (16-35)	11.15	5.41	2.61	48.5	63.4
Boyer [84]	2002	*SD*	174	ND	Male (149); Female (25)	29.5 (17-53)	ND	6.04	2.52	*	*
Gilmore [92]	1973	ND	125	19 - excluded	Male	(18-74)	20	3	12	15	37.5
Heidari [94]***	2007	*SD*	77	ND	Male	35.7	14.2 (7.5)	3.5 (2.7)	6.2 (7.6)	24.6	43.8
Heidari [93]***	2008	*SD*	122	ND	Male	36.4	13.8 (7.3)	3.6 (2.7)	5.7 (7.0)	26.1	43.9
Heng [95]	2006	*SD*	172	ND	Female	34.8	11.3	2.4	4.4	21.2	36.7
Hurlen [97]	1984	*SD*	124	ND	Male	30 (19-62)	19.9	6.2	4.9	31.2	41.3
Shapiro [104]	1969	ND	157	ND	Female	28.54 (16-61+)	16.74	6.61	8.03	39.49	75.89
Shapiro [105]	1970	ND	59	ND	Female	28.6 (16-50)	15.24	7.54	5.86	49.5	80.4
32 teeth examined											
Boyer [84],	2002	*SD*	174	ND	Male (149); Female (25)	29.5 (17-53)	ND	6.87	4.22	*	*
Cavalcanti [71]	2014	*SD*	127	ND	Male	28.5 (18-55)	19.72	11.06 (5.37)	7.20 (7.23)	56.0	88.3
Colon [88]	1972	ND	1,752	92 - excluded	Male	(18-74)	*	*	*	*	*
Heng [96]	2002	*SD*	500	12 - included	Female	36 (18-65)	16.8 (7.3)	3.5 (3.6)	7.4 (7.0)	20.8	36.8
Ormes [101]	1997	*SD*	251	16 - included	Male	33.1 (18-45+)	15.20 (8.13)	2.51 (3.12)	6.35 (7.88)	16.5	28.4
Ross [102]	1977	ND	141	ND	Male (141)	(17-34)	14.7	6.3	6.4	42.9	75.9

* not calculable: group numbers not reported/data missing; ** age data is for entire study but only 94% were examined; *** remand group reported in both studies; ND = data not disclosed; *SD* = standard deviation; *SE* = standard error

Table 2.5 Published reports of caries experience in prisoner populations: other caries indices

First author [Ref#]	Year	Unit of variance	Caries indices	Total exams	Edentate (N)	Gender (N)	$\bar{X}$ age (range), years	Caries outcome measures (variance)
28 teeth examined								
Boyer [84]	2002	*SD*	DMT; DS	173	ND	Male (149); Female (25)	29.5 (17-53)	DS = 15.1 (*SD* = 15.76)
32 teeth examined								
Heng [96]	2002	*SD*	DMFS	500	12 – included	Female	36 (18-65)	DMFS = 57.0 (36.5); DS = 7.3 (9.6); MS = 36.8 (35.1); %DS/DMFS = 12.8; %DS/DFS = 36.0
Number of teeth examined not reported								
Clare [86]	2002	ND	DFS	257	ND	ND	ND	DS = 3.6 [baseline: 6.7]; DS/DFS = 30.5 [baseline: 50.1]
Clare [85]	1998	ND	DFS; Caries Control Procedure (CCP)	1,971	ND	Male (1756); Female (215)	(18-74)	DS = 7.4; DS/DFS = 55.2; CCP = 23% ≥ 1 procedure
Nobile [100]	2007	*SD*	DMFS; root caries	544	7 - included	Males	38.7 (20-81)	DMFS = 37.6 (28.9); DS = 6.4 (9.1); MS = 28.8 (27.5); %DS/DMFS = 17.0; %DS/DFS = 20.8
Rouxel [108]	2013	*SD*	PUFA symptom	103	0	Female	30.9	40% had any PUFA symptom; 39% severe decay with open pulp

ND = data not disclosed; *SD* = standard deviation

2.3.8 Prisoners: high risk population for dental caries

Several authors highlighted greater caries experience and the disparate nature of the prisoners when compared with non-imprisoned (general) populations; see section 2.3.10.3 for further details of studies compared. Higher experiences of tooth loss were noted [81, 90, 102, 103, 108] in addition to higher numbers of decayed teeth coinciding with lower filled dentition [85, 90, 92-94, 98, 101, 102, 108, 109]. When combined, the latter features are hallmarks of less dental treatment received and high unmet treatment need. One study described prisoners as having worse caries experience than non-prisoners living in the most deprived parts of the country [99] and another reported greater DMFT experience among young offenders when compared with adult prisoners in the local area which the authors intimated could be suggestive of worsening caries experience [106].

Few studies reported significant differences in caries morbidity (decayed surfaces or teeth) between prisoner and non-prisoner populations [66, 81, 84, 90]. Where comparisons were made, three determined caries morbidity in the prisoner population to be significantly higher when compared with non-prisoner populations [81, 84, 90] and the findings persisted when adjusted for age and ethnicity [84]. The authors of one study [81] acknowledged it was not possible to control for likely confounders including for example ethnicity and education – a limitation which applies to many of the studies published. In other findings, Jones *et al.* [66] reported no difference for total caries, however severe caries (into the dental pulp) was three times higher in the Scottish prisons population (32 vs 9; $p < 0.001$) when compared with the general UK population.

2.3.9 Determinants of dental caries experience

Root caries was examined in a single article [100] where a significant association ($p < 0.001$) was confirmed with higher Gingival Index scores (measure of health of soft tissue where dentition meet gums) and longer time spent in prison ($p = 0.022$). Nobile *et al.* also concluded several measured demographic and behavioural attributes had no significant relationship with root caries. These were the utilization of dental health care services; frequency of daily toothbrushing; age; sweet consumption; educational level; and marital status.

For coronal caries, multiple risk factors were collectively considered in two studies. For a population of Australian young offenders [106] a multivariate model determined non-fluoridated water supplies, shorter durations of incarcerations, and self-reported dental attitudes were significantly associated ($p < 0.05$) with caries incidence and higher DMFT scores; additionally, geographical remoteness and toothbrushing less than twice a day were significantly associated with caries, and toothache significantly associated with higher DMFT scores. For this young offender population [106], age, gender, 'Aboriginality', experience of being placed in care, socio-economic disadvantage, sugar consumption, dental attendance and location of last dental attendance (inside or outside prison) did not significantly explain caries or DMFT experience. However, a separate study originating from Italy [100] reported a logistic regression model for DMFT where frequency of toothbrushing, age, and dental service utilization *were* significant risk factors alongside plaque; the difference in findings is likely explained by the older population recruited in the latter study. Nobile *et al.* [100] also determined gingival health, time in prison, consumption of sweets, educational attainment, and marital status did not significantly predict DMFT experience. The remaining studies examined fewer determinants for caries experience; the key emerging determinants of dental caries experience are explored below.

2.3.9.1 Demographics

The effects of age, gender and/or ethnicity on caries experience were not comparable across the studies as age was frequently grouped into different age bands, and ethnicity was also not measured consistently. Furthermore, as already identified in section 2.3.6, most of the studies pertained to adult and male prisoners. Nevertheless, where authors did employ statistical methods, they frequently reported associations for DMFT scores and number of decayed teeth (DT), alongside missing (MT) and filled (FT) teeth [71, 81, 83, 89, 96, 101, 103]; two studies examined the association between age and ethnicity and DMFT alone [95, 109].

Four studies reported older prisoners had significantly higher DMFT [71, 81, 95, 96] and higher DT experience [71, 81, 96]. Three identified older prisoners had significantly higher DMFT scores but no significant difference in DT experience [91, 101, 103]. The one study which found no association between age and DT, or DMFT, was limited to young offenders and therefore also a narrow age band [109].

Three studies reported statistically tested differences in caries experience between males and females [81, 83, 89]. A study, of predominantly male prisoners (92%), determined males had lower DMFT scores, however significantly higher DT, when compared with females [89]. A separate US based study, where 75% of the study population were male, found no differences in DMFT or DT by gender [83]. In contrast, a US study [81] determined female prisoners aged 20-34 years of age, had significantly higher DT and DMFT scores, when compared with male prisoners, with no significant differences in younger and older age bands. Whilst the statistical evidence is inconclusive, other descriptive accounts indicate female prisoners experience worse caries experience than males [66, 87].

For ethnicity, the statistically significant comparisons pertained to predominantly 'Non-White' or 'Black' ethnicities, although the findings varied. Three studies identified Caucasian prisoners had significantly higher DMFT experience [81, 95, 96] and, of these, two reported associations for DT where those of 'Black' ethnicity had significantly higher scores [81, 96]. 'Black' ethnicity was also significantly associated with higher DT in another study, [89] although no association for DMFT was found. Conversely, Ormes *et al.* [101] determined no association between ethnicity and DT but some evidence that 'White' prisoners had higher DMFT scores at a younger age. A study of Brazilian young offenders [109] found no association between ethnicity and DT or DMFT as did a US age-matched analysis of male prisoners (including young offenders) [103] and a second US analysis of male prisoners aged 17-34 [102]. Another US survey determined Americans of European origin had higher DT and DMFT experience when compared to those of Mexican, African or Indian heritage [88]. Interestingly, one post-intervention analysis determined improvements in caries experience were not shared equally by those of different ethnicities and that decayed surfaces declined more among those of 'White' ethnicity however this group still suffered greater caries experience when compared to a national population whereas the equivalent figures for those of 'Black' ethnicity were comparable [86].

In consideration of the potential confounding effects of these socio-demographic measures many of the studies reported comparisons for age-, gender-, and/or ethnicity-matched data (see section 2.3.10.3 for further details).

2.3.9.2 Socioeconomic status

Many of the authors alluded to disparities among prisoner population stemming from socioeconomic backgrounds and poorer experiences of education, employment and income [82, 85, 90, 92, 97, 98, 103]. Whilst unsupported by study data, the authors' observations were nevertheless valid and gave important insights into how lower socioeconomic status (SES) was interrelated with a number of relevant risk factors including accessibility of health care, drug abuse, homelessness, social assistance, and attitudes and values [82, 85, 90, 103]. Where adjunct study measures were included, limited educational attainment [71, 93, 108] and high unemployment [71, 93] where found to be highly prevalent; one study examining Anderson's behavioural model of service utilization [107] determined education, employment, and professional qualifications were predisposing factors which influenced dental caries experience both directly and indirectly via enabling factors including dental indifference and dental attendance. A small number of studies included findings for significant differences in caries experience due to SES [81, 84, 95, 97, 109] and are summarized below.

For educational attainment, the evidence for effect on caries experience was mixed. A survey of US female prisoners (aged between 20 and 40 years) [81] concluded high school graduates had significantly ($p \leq 0.001$) fewer decayed teeth and DMFT experience when compared with those who did not graduate. A separate study of US female prisoners (aged 19 to 62 years) determined time in formal education was not significantly associated with DMFT experience [95]. One study of Brazilian young offenders reported schooling was significantly associated with number of decayed teeth but not total DMFT experience [109]. Finally, the authors of a survey of Norwegian male prisoners speculated that the dental service provision the participants were exposed to in early school years was, to some extent, protective [97].

The participants in the Norwegian study also reported that finances were a reason for the poor dental attendance patterns in later years [97]. A separate survey found female prisoners who were employed had significantly lower DT scores although these same prisoners also had significantly higher DMFT experience primarily resulting from more restorative treatment received [81]. Finally, an analysis of caries outcomes among Brazilian male young offenders found family income was not significantly associated with DMFT or DT, however household crowding was significantly associated with higher numbers of decayed teeth [109].

2.3.9.3 *Community environments*

One author expressed the opinion that fluoridated water did not guarantee good oral health experience [88] whereas a second postulated differences across studies could be attributed to fluoride exposure [81]. The use of fluoride applications was also proposed as a means to address the complex dental needs of prisoners [83, 85]. Only one survey included a measure of water fluoridation and found Australian young offenders living in non-fluoridated areas had significantly higher caries experience than those in locations known to be supplied by fluoridated water [106]. The latter study also identified being placed in care and geographical remoteness were not associated with caries or DMFT scores.

2.3.9.4 *Substance (mis)use*

Nicotine [93, 94] alongside alcohol [93, 94] and illicit drug use [93, 94, 108] within the context of misuse or addiction/dependence were reportedly highly prevalent and likely determinants of caries experience. Martins *et al.* [109] were the only authors who reported study measures for all three and made the distinction between patterns of misuse and none or occasional use; despite more than half the male young offenders reporting misuse for tobacco, alcohol and illicit drugs, there was no significant association between any of these three behaviours and DMFT experience or number of decayed teeth. A separate study of male prisoners (19-62 years of age) found higher DT and DMFT scores among those reporting alcohol or alcohol and drug use although no statistical test of association was performed [97].

The relationship between illicit drug use and caries experience was discussed by a number of authors [81, 89, 93, 94, 102, 103] however an association with drug use was recorded in only four studies which, in order of publication date, included male and female addicts (18-43 years (y) of age) [87], males (19-62 y) [97], male and female heroin addicts (16-35 y) [82], and females (19-62 y) [95]. The latter study of female offenders [95] identified a number of drugs (marijuana, cocaine, crack cocaine [crystal form which is heated and smoked] and heroin) but only heroin use had a weak ($p = 0.06$) association with DMFT experience. Historical data (published 1972) [87] reported females with addiction problems to have at least double the number of decayed teeth when compared with males. Another more recent study (1997) [82] also found current or prior heroin addiction was significantly ($p < 0.01$) associated with DT and

DMFT scores when compared to those with no history of addiction. One study found no correlation between drug misuse among male prisoners and caries experience [97].

The relationship between tobacco smoking and caries experience was a primary objective for two studies although notably the population was exclusively female in one [95] and predominantly male (92%) in the other [89]. Heng *et al.* [95] found female smokers had significantly higher DMFT scores than non-smokers and the pack-years smoked were also positively correlated with DMFT experience; however, when the components of DMFT were analyzed separately only MT was associated with number of pack-years smoked. Similarly, Cropsey *et al.* [89] also found no significant association between DT scores and smoking status but significant associations were determined for FT and MT.

The above studies indicate illicit drug misuse and tobacco smoking are both associated with DMFT experience however the two groups likely have, at least some, distinguishable mechanisms or pathways toward poor dental health experience since substance misuse is characterized by higher numbers of decayed dentition whereas smoking seems to be more strongly associated with higher numbers of missing teeth. There are also indications that, for drug misuse, males and females do not share equal experiences in dental health outcomes. The current evidence does not allow for conclusive statements to be made for different experiences among young offenders. The studies also examined possible co-occuring risk factors for caries experience which are précised below.

Smoking was associated with socio-demographics (age and ethnicity) in two studies [89, 95]. One [95] established pack-years smoked alongside age, country of birth, perceived understanding of oral cancer risk, and sugar consumption in tea or coffee were significantly ($p < 0.0001$) associated with DMFT scores; whereas ethnicity, educational attainment were not. Heng *et al.* [95] further cited evidence for a causative link between smoking and caries experience due to the effects of xerostomia and suppression of ascorbic acid (vitamin C).

For illicit drug use, a complex interaction between pharmacological and physiological mechanisms, and social isolation and difficulties arising from limited psychological resilience, emerged from the authors' discussions. Two examiners noted a characteristic caries lesion, among individuals with a drug addiction history, which could be identified from presentation of less pain [82, 87]; this distinguishing lesion was not found in a separate study [97]. Elevated sugar intake was reportedly commonly observed among individuals with a drug addiction [82, 87] and one examiner wrote about their patients use of sugar to alleviate dry mouth symptoms [87]. The link between drug dependence and neglected hygiene was also noted [87, 97]. Within the context of not having access to drugs whilst in prison, withdrawal often coincided with unmasked dental pain [71, 82, 102] which required prescribing of analgesics where xerostomia was indicated as a side effect [82]. One author documented the emotions arising from social isolation and use of mood-altering drugs to cope with these feelings [87]. Colon [87] also identified females may potentially have worse caries experience because their drug dependence arose from more deep-seated emotional turmoil. Colon furthermore highlighted retention of a tooth requiring treatment validated the need for analgesic treatment among patients seeking prescriptions in order to self-medicate [87]. An alternative explanation was pharmacological since one cited study had shown intravenous morphine use exerted (potentially via the adrenal medulla) a hyperglycaemic effect. Colon [87] also referenced a physiological explanation wherein a hypothalamic glucose response to changing circulating glucose levels. potentiated sugar cravings. Colon further commented the preferences for refined sugars (as opposed to solid food) were purposeful attempts to alleviate constipation symptoms.

2.3.9.5 Psychosocial

Psychological distress presented as depression or other psychophysiological reactions requiring greater treatment in the prison setting [67]. Section 2.3.9.4 above highlighted the psychosocial experiences alluded to in examiner–patient interactions where the patient had a history of drug dependence. The mechanisms underlying psychosocial health and inequalities in oral health experience, where there was no history of drug dependence, was not substantively studied. Nevertheless, there is some limited evidence of a psychosomatic element to health service utilization in the prison setting where prisoners have reportedly presented with physical ailments accompanied by hyperbolic concerns [67] and self-reported their concerns about infection control in the prison setting [66]. Separately, as already identified, one multivariate model reported psychotropic medicines did not significantly explain DMFT or DT scores among young offenders [109] although few (14%) were in fact prescribed such medicines.

2.3.9.6 Oral health-related behaviours and attitudes

Several authors demonstrated high dental service utilization whilst inside prison [93, 94] and contrasting poor, or emergency only, dental attendance patterns outside in community settings [71, 81, 93, 94, 97, 108]. These features were also commented by other authors [82, 83, 88, 90, 98, 99, 102]. A study of Australian young offenders found dental service attendance between the two settings did not significantly differ [106] and a study examining smoking-related risk factors among US female prisoners also determined no association between frequency of dental attendances and DMFT scores [95]. Both studies also reported frequency of toothbrushing was not associated with caries experience; one found no association between caries experience and frequent consumption of sugary snacks or preferences for sweetened drinks [106] and similar findings for sugar consumption were determined in the second with the exception of sugared teas and coffees which were associated with significantly ($p = 0.03$, bivariate analysis) higher DMFT scores [95]. A single study examined the relationship between time imprisoned and oral health-related behaviours [91] and found no significant difference in oral hygiene behaviours or dental attendance patterns despite those incarcerated for longer reporting significantly worse oral health and difficulties chewing.

Co-occurring risk factors were also reported, however the information was frequently limited to descriptive reports or author comments; nevertheless these provide insight to the facilitators and barriers faced by prisoners. A study of European prisoners [97] narrated prisoners recollections of regular school-based dental attendances in early childhood years, however, with poorer subsequent attendance patterns in later years. A number of authors theorised extreme dental anxiety as the likely reason for prisoners presenting for emergency care in the community instead of routine examinations [81, 93, 94, 97, 100].

In the prison setting, the availability and accessibility of detoxification/ rehabilitation programmes and/or prohibition of substance use reportedly resulted in prisoners being more receptive to dental care, although it was also acknowledged this was perhaps because they were more aware of pre-existing dental pain [71, 91, 97, 102]. Where dental pain was measured, high proportions of prisoners self-reported current dental pain whilst inside prison [81], or pain as the reason for their last dental attendance [93, 94]. One study, where comparatively lower proportions reported recent dental pain, found no association with DMFT experience [71]. One author theorised that some prisoners may experience difficulties accessing prison dental services [108].

Additional evidence for the prison setting being conducive for improved oral health-related behaviours came from prisoners self-reported increase in toothbrushing frequency [97]. Free toothbrush and toothpaste were acknowledged as being readily available [99] however prisoners also reported these to be of inferior quality [66, 94]. Lunn *et al.* [99] further highlighted the lack of resources available in these secured settings with prohibition of dental floss, interdental brushes and denture adhesive. In contrast for behaviours related to sugar consumption, despite the availability of low sugar snacks, and demonstrated knowledge of effect of sugars on dentition, prisoners self-reported frequent sugar consumption and furthermore identified sugary foods as a source of 'pleasure' or 'comfort' [93]; two additional studies also reported frequent sugar consumption despite implementation of a healthy eating programme [94, 108].

The challenges of the prison setting were also felt by dental service providers, who referenced the fragility in maintaining prison dental services in the context of unavailable dental staff, low budgets, and security impacts e.g. transportation of prisoners [71, 90].

2.3.9.7 Time imprisoned

As previously noted, determinants of caries experience may differ between those imprisoned for many years and those remanded for sentenced for shorter periods of time. Where time imprisoned was examined, the findings for caries experience differed, however this may be explained by differences in time parameters adopted. One study simply grouped participants into 'new prisoners' who had just arrived or 'veterans' [89]; here those newly arrived had significantly ($p < 0.01$) greater DMFT and there was no significant difference in DT experience between the two groups.

Where groupings were more defined, a study originating from France found imprisonment greater than two years significantly ($p < 0.05$) explained more variation in DMFT scores than age, with the difference attributable to the missing component (MT) of the DMFT, no significant difference was determined for DT or FT [91]. A cut-off of less than two years imprisoned in a separate US based study [101] found some indication that DT significantly ($p = 0.05$) decreased and DMFT significantly increased with time imprisoned; no significant difference was determined for MT experience. A UK based study also reported DT experience was lower in those imprisoned for 2 years or more [98].

Three years continuous incarceration was the criteria for a study examining caries experience post-intervention [86] and need for caries control procedures was reportedly unchanged although number of decayed surfaces did decrease.

Where time was analysed as a more linear concept, two studies determined DT to be significantly lower with longer periods of time imprisoned [66, 103] although DMFT experience did not significantly differ in either. One study reported for every 6 months to 1 year of incarceration, the DT declined on average by 1.30 [103] and a second determined a period of 2 years imprisonment was needed to address the DT experience prisoners had acquired prior to imprisonment [66]. The explanation for these improvements may be that short-term imprisonments do not allow sufficient time for prison dental services to complete required dental treatments [66, 83, 99].

For young offenders, Australian youth presenting for dental treatment between 3 months and 12 months after imprisonment experienced higher DMFT scores ($p = 0.05$) than those presenting after 12 months of incarceration [106]. A study from Brazil [109] determined no significance between time imprisoned and DMFT and DT scores although time imprisoned was compared as less, and more, than 5 months.

In summary, the current literature indicates coronal caries experience may be determined by a complex interaction between varied categories of determinants of health including socioeconomic and environmental conditions, living conditions including accessibility of health services, and individual lifestyle (distal) factors such as health behaviours, as well as biological/genetic individual constitutional factors such as age and gender. There is some limited evidence that adult males and females do not share equitable experiences of these risk factors however gender inequalities are less well understood among young offenders.

2.3.10 Quality assessment

Table 2.6 reports an overview of the study risk scores determined for each of the quality assessment domains. The overall study designs were generally appropriate, however for some studies there was evidence of sampling bias. Additionally, incomplete data and missing measures for potential confounders was a source of potential bias for a number of the studies and most did not report the funder or potential conflicts of interest. The findings for each domain are detailed in the following sections.

2.3.10.1 Study designs

Most of the studies were appropriately designed given the stated objectives to determine prevalence of caries experience in specified prison populations. One of the cross-sectional articles examined the effects of drug use on dentition [87] but was deemed to be better suited to a case-control design as exampled by Becart [82].

2.3.10.2 Sample representativeness

The majority of studies were limited to a *single* prison [71, 81-84, 90, 93-97, 99, 102-105, 108, 109, 114] and/or to institutions where there was a strong possibility a sub-population of prisoners was over-represented e.g. by limiting the prison sites to processing centres and those which hold remanded or prisoners serving shorter-term sentences precludes the inclusion of those serving longer-term sentences [85, 86, 100]. Number of sites visited in the remaining studies varied from two [92] to thirty-four [101]. Limited geographical coverage was often acknowledged as a study limitation, or the location bias obviated by stating an objective to determine the prevalence of oral health outcomes in a specific location.

Another potential source of bias introduced in these studies was via the sampling methods and relate to the exclusion criteria. For the majority of studies, all consenting participants were eligible although, where applicable, inclusion/exclusion criteria primarily were adopted in keeping with the stated aims/objectives. Edentate individuals were excluded from a few studies either at the outset [82, 88, 98] or post-data collection phase [92]. Outside the studies of young offenders, age restrictions were also evident in a number of studies and primarily to restrict eligibility to the most commonly observed population ages in prisons e.g. 34 and 35 years of age or greater [82, 102] and in one UK study limited to 20-35 years of age [107]. Two studies excluded ethnicities

Table 2.6 Risk of bias assessment for studies reporting caries experience in prisoner populations

First author [Ref#]	Study design appropriate	Study sample representative	Control/ comparison group	Quality of caries measurements & outcomes	Data completeness	Distoring influences	Funder/ author conflicts
Badner [81]	green	amber	amber	green	amber	amber	red
Becart [82]	green	red	amber	amber	red	red	red
Bolin [83]	green	green	NA	amber	red	red	red
Boyer [84]	green	green	green	green	amber	amber	red
Cavalcanti [71]	green	red	NA	green	amber	red	amber
Clare [85]	amber	green	amber	amber	red	red	red
Clare [86]	green	green	green	amber	red	amber	red
Colon [87]	green	red	red	red	red	red	red
Colon [88]	red	red	red	red	red	red	red
Cropsey [89]	amber	amber	green	amber	amber	green	amber
Cunningham [90]	green	amber	green	red	red	amber	amber
Decerle [91]	green	amber	NA	red	red	red	red
Gilmore [92]	green	red	red	amber	amber	red	red
Haysom [106]	green	amber	amber	red	amber	amber	amber
Heidari [93, 94]	green	red	amber	green	amber	amber	red
Heng [96]	green	amber	NA	amber	amber	amber	red
Heng [95]	green	amber	green	green	amber	green	red
Hurlen [97]	green	red	NA	red	red	red	red
Jones [66]	green	green	green	green	green	green	green
Jones [98]	green	green	amber	amber	amber	amber	red
Lunn [99]	green	red	red	red	red	red	red
Marshman [107]	green	amber	NA	amber	amber	red	red
Martins [109]	green	red	amber	green	amber	red	amber
Nobile [100]	green	green	NA	green	amber	green	amber
Ormes [101]	green	green	amber	green	amber	amber	red
Ross [102]	green	red	amber	red	red	red	red
Rouxel [108]	green	amber	green	green	green	red	amber
Salive [103]	green	amber	amber	amber	amber	green	red
Shapiro [104]	amber	green	red	amber	red	red	red
Shapiro [105]	amber	amber	red	amber	red	red	red

green = low risk of bias; amber = medium risk of bias; red = high risk of bias; NA = not applicable where too few numbers meant between-group comparisons were not possible [88, 97]. In one study, where approximately 60% of the study population were sampled, more extensive criteria excluded those with infectious diseases or exocrine disorders [71]. It is interesting to note that one prisoner was excluded because of ‘extreme dental decay’ [102]. Study representativeness was also assessed by the methodological strategies employed to reduce sampling bias.

Random selection of participants was evident in five studies adopting randomized selection in whole [83, 98, 100, 102, 108] or in part [89, 107]. One author described a stratified 3 stage probability sampling method [101]; and systematic sampling of sequential participants was evident in two studies [84, 95]. These various strategies were combined with a sampling fraction in five instances [83, 95, 101, 107, 108]. Outside of these more stringent sampling methods, the use of a sampling fraction was only adopted in two further studies [66, 92]. Although, to assess the likelihood of a sampling bias, two authors did report representativeness assessments whereby key variables for the study population were checked against prison databases e.g. age, ethnicity [81, 103].

The source of samples was frequently limited to participants either entering a prison facility (i.e. new admissions) [81, 84, 85, 91, 96, 97], or those attending the prison dental service [82, 90, 93, 94, 99]. Thus residents serving longer-term sentences were likely to be under-represented in the first category, and individuals not seeking dental services or those unsuccessful in their application to be seen by the dental service in the latter, resulting in a potential over-estimation of the caries experience.

The final parameter for assessing study representativeness was the information provided for non-respondents. Most authors provided no information about non-respondents, [66, 82, 85, 87-90, 93-96, 99, 103-105] the remaining reported response rates however did not report reasons for refusing examinations [81, 84, 86, 92, 97, 98, 100-102, 106-108]. The risk of bias presented here is that those experiencing caries may not have been available to the researchers, or were available but for unknown reasons refused to take part.

2.3.10.3 Control and comparison reference groups

Many of the authors compared the caries experience for their population of study with external reference groups including non-prison populations [66, 81, 84-88, 90, 92-94, 98, 99, 101-103, 106, 108, 109] and prisoner populations from other settings [81, 84, 87, 99, 101, 103, 106]. Of these, four reported comparisons for lifetime dental caries experience (DMF), however they did not report comparable data for decayed teeth or surfaces (DT/DS) independently [83, 104, 106, 109]; a further five reported summary conclusions with no figures for DMF or decayed dentition [86, 87, 93, 99, 105]. Where between-study comparisons for decayed dentition or unmet treatment need were made, the reference groups were:

- *National* [66, 84, 85, 88, 92, 94, 98, 101, 102, 108] *or regional surveys* [90] *and/or national employed* [101, 103] *or regional employed* [81] all of which were representative of non-prisoner populations. Where comparisons by categories were made, the study participants and reference groups were matched or compared by: age alone [81, 101, 102]; gender alone [66]; age and gender [90, 92, 108]; age and ethnicity [84, 85]; or age, gender, and ethnicity [88, 103]. One study also provided data for social deprivation [98].
- *Other prison-based studies* where the study population and reference groups were matched by age, sex and ethnicity [81, 103] or a mixture of these demographics depending on what data were available for each comparison group [84]; or age grouping only [101].

Within-study population comparisons were reported in six studies:

- A case-control study by Becart *et al.* [82] compared ‘drug addicts’ to ‘non-drug addicts’;
- Clare compared follow-up [86]and baseline data [85] for a defined study population;
- Both Cropsey *et al.* [89] and Heng *et al.* [95], stratified their study groups by smoking status;
- Haysom *et al.* [106] compared Aboriginal and non-Aboriginal youth offenders in Australia.
- Heidiari *et al.* [93] compared remand and convicted prisoners.

2.3.10.4 *Methodological criteria for caries*

The assessment for this domain was focused on the measures and outcomes pertaining to decayed dentition. The data summarised here is limited to the key themes identified. Table 2.3 provides a detailed account of the methodological approaches.

The decayed, missing and filled teeth (DMFT) index was the most common measure of dental caries experience. Two authors also reported the decayed, missing, and filled *surfaces* (DMFS) [96, 100] and only one reported prevalence of root caries [100]. One study excluded fillings thus data were limited to decayed and missing teeth (DMT) [84]. A separate study excluded missing surfaces and only reported data for decayed and filled surfaces (DFS) [85, 86]. Caries control procedures (CCP) required [85], and number of teeth requiring extraction [99], were two further indicators of caries experience. Despite the availability of a commonplace index (DMFT), direct comparison of studies was not feasible for a number of reasons which are outlined below.

2.3.10.4.1 Caries indices / assessment criteria

The diagnostic criteria for lifetime caries (DMF) were frequently not reported [85, 87-91], or were un-standardized in the case of routine dental examination criteria [84, 99, 101]. Where a standardized approach was taken the reported method was frequently selected to allow for alignment to national surveys thus permitting comparison between prisoner and non-prisoner populations [66, 71, 81, 92-94, 98, 108, 109].

The use of standard indices for coronal surfaces were indicated in eight studies which reported the Radike [96], Klein and Palmer [82], or the World Health Organization (WHO) index [71, 97, 100, 102, 106, 109]. One author provided a reference for root caries assessment [100]. The Association of State and Territorial Dental Directors (ASTDD) manual [100] was referenced in one study however criteria for caries assessment could not be determined from this referenced article. The use of a standard index did not however translate to direct comparability, for example the authors adopting the Radike criteria [96] reported the missing (M) component of DMF was used to record missing dentition not attributable caries, which is not consistent with the Klein and Palmer and WHO indices where M is typically reserved for when missingness *can* be attributed to caries.

Diagnosis of caries morbidity is dependent on a number of factors including a) criteria for caries assessment, b) use of equipment (e.g. probes) to aid visual examinations, and c) use of radiographs to aid diagnosis of caries not visually detectable.

Most authors stated a probe/explorer and mirror was used in the examinations performed [66, 71, 82, 84, 85, 92, 96, 100-105]. Only two studies described the severity criteria for a tooth/surface to be counted as carious [84, 92]. Use of radiographs was confirmed in 7 articles [84, 87, 95, 96, 99, 101, 103] whereas 13 provided no information regarding this parameter thus availability of radiographs to aid diagnosis could not be determined [66, 71, 81, 83, 86, 89-91, 93, 106-109]. Where radiographs were reported, two studies [84, 103] specified panoramic radiographs which have been reported to have limited application for the diagnosis of caries since they are of lower resolution and the "premaxillary region" (i.e. canine and premolar dentition) is often obscured by the superimposed spine [115] thus impeding caries diagnosis within this area.

2.3.10.4.2 Number of teeth examined

For valid comparisons to be made, the number of teeth examined is an important consideration when comparing data from different studies. Sixteen studies gave no information in this regard, [66, 81, 83, 85-87, 89-91, 98-100, 103, 106-109] and the remainder were a mixture of 32 and 28 teeth. Boyer *et al.* were the only authors who provided data for both 28 and 32 teeth [84].

2.3.10.4.3 Other methodological criteria

Examiner bias was addressed using a variety of methods including use of a single examiner (thus eliminating inter-rater bias) [71, 83, 88, 90, 93-95, 103, 108, 109]; conducting chart/case reviews [81, 103]; or training [84-86, 89, 98, 100, 107, 108] and calibration exercises [71, 89, 95, 98, 100, 107-109]. Examiner reliability scores were given in six studies [66, 71, 89, 93, 94, 108, 109].

The use of standard data collection forms/questionnaires [71, 81, 82, 84-86, 89, 92, 95, 103-105, 109] was another reported method to improve the rigor for data collection. Interview methods, increasingly so in more recent studies, were employed since literacy skills were identified as a limiting factor for completion rates [71, 89, 93, 94, 106-108].

2.3.10.5 *Data completeness and extraneous factors*

The domain for *data completeness* was influenced for various reasons e.g. age of participants, unit of variance for caries experience, exact *p*-values, protocol for missing chart data, number of non-respondents, or reasons for refusals, were not reported. Consideration was also given to the reporting of extraneous factors affecting the population of study/examinations performed, as well as statistical analyses performed. Most articles omitted information for both the funder and author conflicts.

2.4 Review limitations

The review was limited to the criminal prisons population and therefore expressly excluded articles reporting vulnerable populations in other institutionalized settings. Whilst there are clear similarities in terms of the regimentation and security incumbent in these settings it is likely the non-judicial settings encapsulate populations with specific determinants of health that cannot be generalized to the correctional imprisoned population e.g. psychosocial needs. Separately, the full-texts of a considerable number (22) of eligible articles were not retrieved which impacts the partiality of this review. The literature search was restricted to the english language and to the peer-reviewed literature; since prisoner populations are unlikely to be a high priority for funders, or indeed of priority interest to journal editors, it is reasonable to assume that the population of interest may not be fully represented. The effects of potential under-representativeness were mitigated to some extent by supplementing the electronic database search with hand searches and a review of the OHHR Prisons database. Nevertheless, the relative priority of this population to editors may mean that some articles were published in low or no impact journals, a noted factor in the reporting quality of important methodological criteria (see Table 2.6) [116].

The external validity of reported caries findings is negatively influenced for a number of reasons, for example effect sizes were frequently unreported with only 15 studies indicating the standard deviation or standard error; number of teeth examined were not stated in almost half the studies; the use of radiographs to aid diagnosis of approximal caries was variable or not reported at all; and crucially the diagnostic criteria for caries were varied or not reported. These fundamental variations persist despite having been highlighted in the past literature [74, 84] and precluded a meta-analysis. Combined with likely over-representation of male inmates presenting at prison dental services (in reference to recruitment strategies frequently adopted) caution must be taken in generalizing the findings to other prison populations. In particular, high-risk young offenders and females are underrepresented as are older prisoners which is especially important since prison populations in industrialized countries are ageing [10].

Whilst there is notably higher caries experiences in the earlier studies published, consideration should be given to a cohort effect whereby the differences in the period post-1970 were influenced by external environmental factors such as public health programmes and policies including the fluoridation of water supplies.

2.5 Review discussion and conclusions

Dental caries experience amongst prisoners has been documented in a number of cross-sectional studies many of which originate from the US where dental examinations for newly admitted prisoners are frequently mandated [117]. There has been a sustained pattern of greater caries experience among prisoner populations when compared with the general non-correctional population. The heterogeneous nature of methods and resultant limitations when generalizing findings to other prisoner populations have persisted despite these weaknesses being highlighted in a recent review published in 2008 [74]. Furthermore, the caries detection systems adopted predominantly excluded early stage incipient caries lesions, very few assessed root caries experience, and radiographs were not commonly utilized; collectively these methodological criteria indicate the extent of dental caries experience has likely been underestimated.

Where efforts have been made to provide dental treatment, or implement a preventive programme, it appears, from the absence in the literature, evaluation measures do not routinely include measures of change in caries experience, as only one such study was reported [86]. In the latter post-intervention study, the published information also did not allow for interpretation of how the observed improvements in caries experience could be attributed to intervention design. Since prison dental services are in high demand, the findings are unsurprising and cost-effective solutions to evaluations of oral health improvement programmes should be considered. Within the Scottish Oral Health Improvement Programme (SOHIPP) both quantitative and qualitative methods and the inclusion of all stakeholders including prisoners and prison staff have been considered [118, 119] and were possible within the framework of existing collaborations between prisons, NHS and academic research staff. Multi-disciplinary efforts to minimize costs whilst securing professional expertise or educational opportunities for prison dental care have also been documented by others [120, 121] although not always with positive feedback as shown in one study of dental students [122]. Whether such programmes reduce caries experience is not however well-understood and should be a consideration for those undertaking evaluations in the future.

Despite being in the midst of an era of 'big data' there were no national database repositories documented and longitudinal surveys have not been routinely undertaken; without this information it is difficult to conclusively determine how the prison setting modifies caries experience. Whilst the availability of longitudinal data would be of tremendous value in the examination of risk factors/indicators over time [84, 103], the practical application in the prison settings is perhaps of limited value since this population is not static and frequently moving, either to the community or to other facilities, or cycling between community and prison settings. Moreover the feasibility of conducting long-term research in these secure settings is likely to be both difficult and cost-prohibitive thus affecting the robustness of data that can be gathered. Although the use of self-report data is valuable, ideally disease experience should be clinically measured to verify the reliability of responses [123].

The current literature provides indications that, for some prisoners, the prison setting is conducive for improved oral health-related behaviours, however for others this setting presents them with different challenges which they struggle to overcome. The concept of changing determinants of health between community and prison settings has been conceptualized by Marquart *et al.* [123] who reported the 'pre-institutional dimension' was subject to modification in the transition to institutional environments where different risks, health services and social roles influence prevalence and severity of disease experience.

Risks for dental caries experience in the prison setting have centered on lack of oral hygiene resources, use of medicines including methadone maintenance therapy which may exacerbate dry mouth symptoms, and sugars from methadone and snacks available for consumption. Availability of many oral health resources including dental floss and mouthwash (containing alcohol) have been prohibited in prison settings [99] although the use of high fluoride toothpaste is an unknown entity. Whilst methadone is known to be sugar-rich, there is no robust evidence of a link with dental caries [60] and the general prison population were documented to frequently consume sugared beverages [95] as were prisoners with history of drug addiction [82, 87]. Moreover, many prisoners chose to consume sugary snacks and drinks despite the implementation of healthy eating programmes [94, 108]. In the UK, the current price difference between sugar (£1.35) and sugar-free (£2.08) methadone oral solution (100mL, 1 mg/mL) may influence prescribing practices where there are budget constraints [124]. The wider sources of sugars should also be considered alongside reports of necessitated sugar-intake to alleviate symptoms associated with xerostomia or other addiction-related symptoms [87]. Whether those dispensing medicines with dry mouth as a side effect are providing supplementary guidance is unknown, and dry mouth experience is associated with smoking which is also highly prevalent in the prisons population [125].

Access to rehabilitation programmes was, at least partially responsible, for increased dental service utilization in the prison setting; however inequitable access was also evident. Those incarcerated for short-term periods in particular did not benefit and, whilst shorter imprisonments may obviate treatments requiring multiple dental attendances, the use of throughcare programmes to ensure opportunities for continuation of treatment after liberation have not been documented. For the community setting, there was some suggestion that financial limitations may have prevented dental attendance however these reports should be interpreted with some caution since, in some countries, for example the UK, healthcare is free at the point of delivery but this does not apply in others, for example the US where many of the reported studies originated.

There was limited information about how social roles influence dental caries experience in the prisons populations. In the wider literature for young offenders, a familial link has been indicated [126, 127] and in particular maternal dental health is an important factor [127], which may arise from inequalities in education and employment [81, 84, 127]. Prisoners distrust of dental staff to maintain effective infection control procedures was a source of particular anxiety [66] and difficulties establishing and maintaining trusting social interactions are a known barrier for improving health experience, including dental health [70, 73]. Social exclusion is likely compounded by the stress experienced by prison staff [128] and the social hierarchy among prisoners.

The presentation of caries experience in the prison setting does not detract from the underlying issue that prisoners will often present to these institutions with pre-existing disease acquired in community settings. Emerging from the literature is a complex interaction of various determinants of dental caries experience which likely arise from lower socioeconomic status (SES) backgrounds. The link between poverty and inequalities in health experience has been proposed by Dahlgren and Whitehead [50] and documented in a review by Marmot [129] where the modifiable nature of key social determinants of health are also highlighted. For the prisons population, where the strength of the evidence is strongest, the determinants of caries experience studied were limited to individual hereditary elements, i.e. age and gender, or common risk factors already of high priority in the prisoner population e.g. addiction, smoking and duration of incarceration [57]. Outside of oral health, SES and poor literacy has been linked to drug addiction in the prisons population [130] as has the use of drugs and crime to reconcile a life of poverty [131] where for some drug use was a gateway toward a life of crime, imprisonment, intravenous drug use and homelessness [132].

There are some indications that the determinants of dental caries experience are not ubiquitous among the prisons population, however understanding which sub-groups share risk or protective factors is poorly studied. The barriers and enablers both inside and outside of prison are also not universally experienced, although there are a number to be considered for the prisons population [70]. For example, the current evidence indicates reduced fluoride exposure is a greater risk factor among young offenders, gender disparities [66, 133], likely arising from SES, appear to become more observable among older prisoners [134, 135], and females may have had greater struggles, for example, with substance misuse [87].

Since no study has comprehensively considered risk indicators for total obvious caries experience between these potentially vulnerable sub-populations in prisons, it is difficult to make conclusive recommendations for future oral health improvement programmes. This thesis sought to address this knowledge-gap by determining differences in dental caries experience and potential risk indicators between females and males, and younger and older prisoners. The review findings were used to inform the subsequent study design and conduct with regard to examining potential risk indicators for dental caries experience and ensuring these captured measures of the wider determinants of health as conceptualized by Fisher-Owens *et al.* [136]. The conceptual framework proposed by Fisher-Owens considers individual level influences alongside family and community influences e.g. health behaviours, SES, social support, and the physical environment. The study was also designed to be sensitive to the enabling or impeding factors which may influence an individuals perceived healthcare needs, as proposed by Andersen and Newman [137] e.g. dental-related attitudes and psychological characteristics.

The study data were derived from the SOHIPP oral health survey [70] and the measures included for analysis as potential indicators were selected with a view to examine as many risk and protective factors explored in the current literature including for example age; gender; education and other measures of socio-economic position; oral health behaviours including toothbrushing; sugar consumption and dental attendance; dry mouth experience; health risk behaviours including smoking and drug use; psychosocial health; and the impact of prison setting. The analysis sought to assess all potential indicators across the prison populations surveyed and determine if the sub-populations of interest differed in terms of the risk indicators which best explained caries experience. Section 3 sets out the methods for data collection and the analysis undertaken for this thesis.

3 Research methods

3.1 Overview of study design

The Scottish Oral Health Improvement Prison Programme (SOHIPP) oral health survey was a prison-based cross-sectional survey designed to assess the dental caries experience of prisoners using the International Caries Detection and Assessment System (ICDAS) methodology alongside self-report participant data across a number of caries related determinants of health and related health conditions. The three survey sites in Scotland were selected to constitute a non-probability convenience sample of distinct prisoner populations: male young offenders, adult male offenders and female offenders. Prior to survey, site visits to each location were organized with the healthcare managers of each facility. A pilot survey was carried out in one prison site during March 2011 and subsequently followed-up with the main fieldwork phase in October and December 2011.

All data were recorded on a single data collection form which comprised two sections i) self-report questionnaire data and ii) dental examination. Dental caries was assessed using the International Caries Detection and Assessment System (ICDAS). The examination was performed on all surfaces of all 32 teeth (where present) by two teams with a dentist (Paul Cushley (PC); Rajneet Minhas (RM)) and a researcher (Tahira Akbar (TA); Markus Themessl-Huber (MT-H)) in each. An assessment of plaque prevalence and severity was also made (data not reported here). No radiographs were taken and no assessment of dry mouth was made in the course of the examination. Dental examinations continued in each residential hall visited until all consenting inmates had been examined or until fieldwork ended. The survey methods are detailed further in the sections below.

3.2 Ethical considerations

The SOHIPP oral health survey received ethical approval from The National Research Ethics Service (Ref no.10/S0501/10, Appendix 9.2) and subsequent approval from the Scottish Prison Service (SPS) Ethics Committee. The key ethical considerations for this study were that all eligible prisoners could freely choose to take part without any constraint or coercion. The participant information material and discussions about participation with TA and the other attending researcher were designed to emphasize the voluntary nature of the study and to stress that dental treatment would not be provided during the course of participation. Where participants requested access to treatment they were signposted to the institutional set-up for requesting treatment (self-referral form). Whilst it is acknowledged the length of sentence is an indicator of severity of offence, to protect prisoners from any preferential treatment, researchers and examiners were not permitted to ask any participating prisoner the nature of the offence for which they were incarcerated. Moreover, all researchers involved in this study were working within the wider SOHIPP programme and both examiners were experienced in conducting dental surveys for epidemiological research.

3.3 Consent procedures

All inmates were eligible for participation with the exception of those who did not understand English and those deemed as high security. In the week prior to survey date(s), the prison management arranged for information posters (Appendix 9.3) to be displayed around the residential hall and key information areas e.g. notice boards. Prison staff also arranged for participation packs containing participant information sheet, consent form, (Appendix 9.4) and data collection instrument (Appendix 9.5) to be distributed the day just prior to survey and, if required, additional questionnaires were distributed on the day of survey. During the survey visit, all examined participants were required to present their completed consent form to the research team prior to any examination taking place. Where the participant was unavailable for examination, each participation pack was checked for a consent form prior to being scanned and stored in an electronic database.

3.4 Sampling locations

The prison sites were selected to constitute distinct prison populations: adult long-term male offenders (HMP Shotts), male young offenders (HMYOI Polmont), and both adult and young offender females (HMP&YOI Cornton Vale). Further details about each location visited are provided below: [138]

Her Majesty's Prison (HMP) Shotts is Scotland's main maximum-security prison facility for holding adult male offenders serving longer-term offences (4 years and over). The prison also holds male offenders serving longer-term offences of 8 years or more although this latter group is typically eventually moved to mainstream prisons after a period of induction/orientation. It is important to note that HMP Shotts was moved to a new purpose built facility in 2012 however for the oral health survey described herein all the preparatory work, pilot survey and the final survey took place in the original neighboring facility (built 1978) which is geographically sited in the same local area (Shotts). The surveys took place in Hall B and Lanont Hall, levels 1, 2 and 3.

Her Majesty's Young Offenders Institute (HMYOI) Polmont is Scotland's only dedicated facility for holding male young offenders (aged 16-21 years of age) and as such holds young offenders serving a range of sentence lengths in addition to those awaiting trial or sentencing. The facility does have separate segregation cells however the survey was limited to one of the three mainstream residential halls: Iona Hall (Monro Hall and Blair House were not visited).

Her Majesty's Prison and Young Offenders Institute (HMP&YOI) Cornton Vale is Scotland's main prison facility for holding female offenders of all ages including young offenders. Whilst the prison is separated into six housing blocks, for the purposes of this survey only five of these were visited: Bruce House, Peebles House, Ross House, Wallace House and Younger House (Skye House was not visited). Cornton Vale also has a small number of independent living units (ILUs), in the form of detached small self-contained housing facilities, which are typically reserved for prisoners nearing the end of a long-term sentence; these latter sites were not visited during the survey.

3.5 Sample size

A sample size of 100 prisoners per prison site was sought. Based on the figures for average daily population and maximum number of prisoners held in these prisons during the period 2010-11 and 2011-12, [139, 140] the lowest possible sampling rate was determined to be 13% (HMYOI Polmont) and the maximum possible rate was 34% (HMP&YOI Cornton Vale), see Table 3.1.

Budgetary constraints limited the staffing resources available for data collection thus, a sample size of 300 (100 participants per prison) was sought from the outset. A post-hoc power analyses (see Appendix 9.9.6) determined the study was sufficiently powered to detect moderate effect sizes when examining all participants together, however the study was less powered to detect even large effect sizes across the three prison populations included.

Table 3.1 Estimated sampling rates for SOHIPP survey

	Average daily population		Maximum number		Estimated sampling rates (%)
	Men	Women	Men	Women	
2010-2011 Prison statistics [139]					
Cornton Vale	-	379	-	438	22.8-26.4
Shotts	536	-	543	-	18.4-18.7
Polmont	732	-	778	-	12.8-13.7
2011-2012 Prison statistics [141]					
Cornton Vale	-	289	-	381	26.2-34.6
Shotts	555	-	598	-	16.7-18.0
Polmont	737	-	784	-	12.8-13.6

3.6 Fieldwork preparation

3.6.1 Researcher and examiner training

All University of Dundee staff, participating in the SOHIPP programme, were required to apply for an Enhanced Disclosure via Disclosure Scotland (an Executive Agency of the Scottish Government). The disclosure report generated is a record of the applying individuals criminal history information held by the police and government departments and is frequently adopted by Scottish employers seeking to make safer recruitment decisions particularly where vulnerable groups are concerned.

For security purposes, all staff (including examiners and researchers) were required to attend a SPS approved Breakaway training session delivered by trained officers at the SPS College, Polmont.

The two dental examiners were recruited from the Public Dental Service, NHS Forth Valley. Both examiners had experience of epidemiological fieldwork through involvement in previous national studies, local oral health surveys co-ordinated by British Assocation for the Study of Community Dentistry (BASCD) and the 1998 Adult Dental Health Survey, United Kingdom [142]. NHS Forth Valley Research &

Development (R&D) approval was given for the two dental examiners (PC and RM) to take part in the study (R&D ref: FV 574).

A dedicated training session for the SOHIPP Oral Health Survey was organised (Raploch Community Campus, Stirling) and attended by all staff participating in the survey. The training session was tailored to ensure both examiners and researchers understood the SOHIPP protocol and operational procedures. To ensure the dental examinations were standardized, an ICDAS Co-ordinator (Professor Gail Douglas, Leeds Dental Institute) delivered the ICDAS training. The ICDAS content was designed, in line with the ICDAS e-learning course [143], to include coverage of the examination protocol and the scoring criteria. The examination protocol included standardized content, e.g. tooth surfaces and surface boundaries, and was further tailored to ensure coverage of the approved SOHIPP study protocol, e.g. unavailability of compressed air for air-drying and design of dental chart within context of recording dental findings. Scoring criteria for caries and restorations were detailed and the training materials included a number of photographic examples which covered the range of caries codes. The study dental examiners were asked to assess the images whilst blinded to the correct answers and the answers were subsequently reviewed with detailed explanation.

All SOHIPP fieldwork was co-ordinated by TA who also collected the questionnaire data.

3.6.2 Operational strategy

In the year prior to survey, at the request of the SPS, a small operational working group was established to review and agree an acceptable strategy in consideration of the research requirements and logistics of conducting the study in the prison environment e.g. risk assessments and security, access required, protocols and equipment requirements, timings of surveys. The working group included representation from the SPS, prison healthcare managers, lead dental examiner, and members of DHSRU.

During the planning phase the use of an online data collection form was briefly considered however it was felt it would not provide any additional benefit but did present concerns in relation to infection control and security in the prison setting. Consideration was also given to the use of a battery powered toothbrush as an incentive;

due to the security concerns (electronic components that could be taken apart) it was decided a regular manual toothbrush and toothpaste would be provided for each consenting participant. It was also agreed two prison officers should be available during the examinations to transport and provide security to the research team. These escorting officers would be available as a result of extra hours (overtime) available for the duration of the survey and therefore should not detract from any existing security arrangements. Prior to survey, as per standard NHS protocols, the dentists performed an independent risk assessment for each site.

An initial pilot study was conducted in HMP Shotts due to the more ‘stable’ nature of prisoners’ lifestyle in that prison since it houses longer-term sentenced prisoners. From the pilot phase, literacy was identified as a potential barrier to recruitment. As a result it was decided that, wherever possible, participants would be offered assistance to complete the form – either in the form of interview or assistance by reading out the questions in order to facilitate self-completion of the form. Such assistance was decided on an individual basis and examiners/researchers were not advised of literacy barriers in advance. The acceptability of a manual toothbrush with toothpaste as an incentive was confirmed and these were subsequently circulated alongside the questionnaires. Questionnaires were circulated the day prior to survey in order to boost participation rates without impacting the completeness of the self-report data. From the clinical examinations, it was determined access to a sink would be needed in order to permit prisoners, as required, to brush their teeth prior to the ICDAS examination. Where this was required, participants were asked to either brush without toothpaste or rinse their mouths after brushing to ensure the tooth surfaces were free of food debris and visible for the caries assessment.

Following the pilot, extensive consultation was undertaken with health care management to ensure a comprehensive risk assessment was completed. Consideration was given to the research requirements including:

- Study protocol: self-report questionnaire and clinical examination
- Equipment/materials required including incentive (toothbrush/toothpaste pack)
- Suitable consultation room for examination: including appropriate lighting and ability to maintain confidentiality
- Disposal of equipment utilised during oral health examination (e.g. probe)

- Safety procedures and security concerns
- Measures to minimise impact on prison staffing resources.

3.6.3 Data collection instrument

The standardised paper form for the oral health survey (see Appendix 9.5) was produced by TA in collaboration with NHS Education for Scotland (NES) eForms services at Dundee (LC) who provided design consultation and advice on the layout and suitability of a form for the purposes of optical scanning at the eForms Office (Ninewells Hospital & Medical School, Dundee). The final design of the form included both the self-report questionnaire data sections and the clinical examination findings in addition to the CRIB sheet for the ICDAS scoring system. The cover art depicts a painting titled 'Self-Portrait with Toothache' which was painted by a prisoner at HMP Grendon (Courtesy of The Koestler Trust). Each page to be scanned was indexed by a barcode at the lower left of the page. Copies of the final version were printed at a professional printing service at the University of Dundee (Design-Print-Marketing [DPM]).

All of the forms were designed to be optically scanned with the exception of the dental chart data which were manually entered by TA; whilst it was hoped the chart findings could also be optically read, handwriting recognition errors precluded this approach. To facilitate the different data entry techniques, each page was coded with a unique anonymised participant identifier before being taken apart. Data to be optically scanned was initially marked up with a highlighter, to ensure scanning reliability, before being securely transferred to eForms where data were captured electronically in an Excel file and then securely transferred back to the researchers. For the manual entry of ICDAS chart data a Microsoft Access database, with a data entry form designed to mirror the paper form chart, was adopted. Since the unique participant identifier was common to both the optically scanned data and the chart findings this identifier could be used to index and merge the separate datafiles in IBM® Statistical Package for Social Sciences (SPSS®) [144].

3.7 Fieldwork procedures

3.7.1 Administration of survey

Prior to survey, site visits to each location were organised via the healthcare managers of each prison and suitable dates for survey were agreed. In preparation for the survey at each facility, participant packs were organised and assembled (by TA) containing the data collection form (see Appendix 9.5), participant information sheet, and consent form (see Appendix 9.4). The survey forms were coded with identifiers to denote the prison and a unique identifying number for each participant. The packs were sent to the prison establishment alongside A3 and A4 posters (see Appendix 9.3). Prison healthcare management were asked to arrange for the posters to be displayed for at least one week just prior to the scheduled study visit. Additional questionnaires, if required, were distributed by researchers on the day of survey and all completed forms were brought back to the University of Dundee for processing and archiving.

All materials/equipment (see 3.7.2 below) brought into the prison had to be taken through security as per standard prison protocols. All dental examinations were performed by two trained teams of a dentist and a researcher each accompanied by a prison officer. During the site visits, the dental teams were allocated a suitable room in each residential hall visited. The prison officers arranged for prisoners to be presented at the examination area for consecutive examinations. Participants were asked to present for a dental examination alongside their consent forms and the survey form. Written consent was required for each form collected and before an examination was performed. If assistance was required to complete the questionnaire it was provided at this stage. The incentive (toothbrush and toothpaste) was also dispensed at this time. Dental examinations continued until all consenting inmates had been examined or until fieldwork ended.

The pilot phase was completed 30th March 2011 (HMP Shotts, Hall B) and the remaining fieldwork took place Oct 26th 2011 (HMP Shotts, Lanont); Oct 5th and Oct 12th 2011 (HMYOI Polmont); and 21st Dec 2011 (HMP&YOI Cornton Vale).

3.7.2 Equipment

A standardised data collection form (section 3.6.3) was used to collect self-report information and the findings of the clinical dental examination. No radiographs were taken in the course of this study and all clinical examinations were performed under field conditions in the prison residential halls, with no access to a dental chair/surgery. For the clinical exam, the equipment required included sharps bins, yellow bags, standard rubbish bin, suitable desk and chair, access to sink or container for used water, Daray V Lights, disposable gloves, cotton wool, and the disposable examination kit which included a single-use sterile mouth mirror and periodontal sickle probe (Kerr Pinnacle 8600-1). Each examining team consisted of one calibrated dentist (see training details above), one researcher who scribed the charts, and a prison officer for security purposes. The remaining resource was the approved incentive consisting of a toothbrush and a toothpaste tube (AMS International, ASPK1450 Toothbrush packs).

3.7.3 Data storage

All survey and consent forms were returned to the University of Dundee for processing. The self-report data were processed following the procedures documented in section 3.6.3 and the dental charts were manually entered by TA. An independent researcher (Sheela Tripathee (ST)) randomly selected charts from each prison and verified data entry. The data collected was pre-anonymised with a unique identifier however the electronic database originally retained the Date of Birth field: this was converted to age, in years, and subsequently removed from the dataset prior to the data being made available for analyses. Since researchers do not have access to any prison or NHS database, this step was not required, nevertheless it was felt best practice to do so. The outliers (more than 1.5 interquartile ranges below first quartile or above third quartile) for all fields were checked against the completed forms and random forms were selected for verification of data entry accuracy. The consent forms and paper questionnaires were stored separately in a secure University location and all electronic data were stored on encrypted University computers.

3.8 Study measures

3.8.1 Self-report questionnaire data

In the first part of the survey, consenting prisoners were asked to complete a self-report questionnaire; the simplified structure and the variables included followed the core content recommended by the WHO for oral health surveillance [145] and which had been adopted in the United Kingdom Adult Dental Health Surveys of the general (non-prisons) population e.g. socio-demographics, employment, education, living arrangements, medical history, dental attendance, and oral health-related behaviours. Additional questions of interest included dental attitudes, prison experiences including number and duration, and psychosocial health including dental anxiety (Modified Dental Anxiety Scale [MDAS]), and depression (Center for Epidemiologic Studies Depression [CES-D]). By including these measures the SOHIPP study was able to expand upon the WHO concept and consider a conceptual framework based upon Fisher-Owens *et al.* work [136], wherein multiple interacting factors affect general health and oral health, combined with measures sensitive to the enabling or impeding factors which influence an individuals perceived healthcare needs, as proposed by Andersen and Newman [137].

The original wording for all questions can be found in the data collection form (Appendix 9.5) and the original survey responses are reported in Appendix 9.6. Variables informative for prediction of dental caries were selected for the present study and their descriptive statistics assessed to ensure sufficient numbers in each comparison group both for the whole population and between-prison populations (women, male young offenders, long-stay adult males). Where there were insufficient numbers for categories of a categorical variable (e.g. < 5 observations for a well-defined characteristic, or < 15 for a *less* well defined characteristic) categories were collapsed where it was meaningful to do so. The resulting categories were again assessed for observations before a decision to remove the variable entirely was made. The questionnaire measures explored in the present study are described below.

3.8.1.1 Socio-demographics

Since the majority of prisoners were of 'White' ethnicity it was not feasible to examine the relationship between ethnicity and dental caries experience. The socio-demographic data explored included:

- **Age**: continuous measure calculated in years from the date of birth;
- **Gender**: male or female;
- **Attained education:** original data in years was dichotimised using the legal school leaving age in Scotland [146] as a cut-off i.e. aged 16 years or over and aged under 16 years;
- **Employment**: data collected included unemployed, employment (full- or part-time, or casual), education (full- or part-time) and training positions. To ensure

sufficient numbers for statistical tests of comparison the data was re-classified into two groups: i) unemployed and ii) employed or in education (i.e. all other categories);

- **Social occupational position:** job titles were reported in a free-text field. Responses were reviewed and grouped using the Standard Occupational Classification (SOC) 2010 system which identifies occupations in relation to required 'qualifications, training, skills and experience' [147]. The SOC occupational categories analysed were: i) Managerial and Professional, (Associate Professional and Technical Occupations; Managers, Directors and Senior Officials; and Professional Occupations) ii) Intermediate (Administrative and Secretarial Occupations; Caring, Leisure and Other Service Occupations; Skilled Trades Occupations), and iii) Routine and Manual (Elementary Occupations; Process, Plant and Machine Operatives; Sales and Customer Service Occupations);
- **Marital status:** i) single, ii) married or cohabiting, and iii) separated, widowed or divorced);
- **Children**: responses to two questions (have any child/ren, child/ren living with you before prison) were combined into a single variable encompassing whether respondents had child(ren), and if they were resident parents;
- **Living circumstances:** accommodation just prior to prison (grouped as stable and non-stable), and history of homelessness (including length of time homeless) or being placed 'in care';
- **Prison experience**: number of prior imprisonments either remanded or sentenced, time spent in prison (calculated in years), and scheduled duration of current imprisonment (less than or more than 4 years).

The data for marital status and children were included to assess family circumstances.

3.8.1.2 Health conditions and medicinal-related xerostomia indicated

Where information was listed for prescribed medicines the individual drugs were cross-referenced against the British National Formulary (BNF) Online [124]. An indication of xerostomia (dry mouth) was recorded as a potential risk factor where this was indicated as a side-effect and irrespective of whether the side effect was common, uncommon or of unknown frequency. The survey also included self-report data for a range of health conditions known to share common risk factors with dental caries: diabetes, angina, heart attack, blood pressure, infectious disease, asthma or lung disease, epilepsy, allergies, blood disorders and pregnancy. To ensure sufficient numbers for comparison these data were collapsed into a single variable grouping respondents with and without any one of the afore listed health conditions.

3.8.1.3 Health risk behaviours

Exposure to known health risk behaviours was assessed across a number of measures including: current smoking; number of cigarettes smoked per day; history of substance use (any illegal drugs; and intravenous drug use alone); history of taking part in a rehabilitation programme. Where grouping categories were combined into a single variable, a response of ‘Don’t know’ or ‘Prefer not to say’ was treated as missing data.

3.8.1.4 Dental health behaviours

Dental behaviours included toothbrushing and sugar consumption between meals both at home and in prison; history of attendance for a preventive dental treatment (scale and polish, fissure sealant, or fluoride treatment); time since last dental attendance (in or outside of prison); and history of attendance at a prison dentist (yes/no).

3.8.1.5 Dental attitudes

Attitudes toward dental treatment were explored by (i) reason for last dental attendance (check-up, experiencing difficulties, or other or unknown reason); and (ii) treatment preferences for an aching back tooth requiring treatment (filled, or taken out), and preferences for a front tooth requiring treatment (crowned, or taken out).

3.8.1.6 Dental anxiety

Dental anxiety is a potential indicator for individuals who experience symptoms of psychological distress when attending for dental treatment/check-ups. In the most extreme cases dental anxiety may prevent a participant from getting dental treatment. The Modified Dental Anxiety Scale (MDAS) was used to assess dental anxiety in participating participants [148]. The scale is based on the sum of five items, which assess anxiety: prior to dental treatment tomorrow, in the waiting room, and when about to have teeth drilled, teeth scaled and polished and a local anaesthetic injection. All items are coded 1 to 5 for responses ‘not anxious’ to ‘extremely anxious’. Thus the

MDAS scale ranges from 5 to 25; a final score ≥ 19 is considered 'extremely dentally anxious' or dental phobia.

3.8.1.7 Depression

The Center for Epidemiologic Studies Depression (CES-D) scale was used to assess depression [149]. The scale is scored by the sum of responses to 20 statements regarding different depressive symptoms, such as, I thought my life had been a failure, I felt depressed, I felt lonely (see Appendix 9.5). The answers are measured on a 4-point scale ranging from 0 to 3 based on the individuals' experience of the statement over the last week (< 1 day to 5-7 days). Thus the final CES-D score ranges from 0 to 60 and where a score of ≥ 16 is indicative of clinical depression.

3.8.2 Physical examination & derivation of summary measures for statistical analyses

The dental examination formed the second part of the SOHIPP survey, this consisted of four individual assessments: oral mucosa, plaque score, denture status, and International Caries Detection and Assessment System (ICDAS) dental assessment. As equipment to air-dry was not available for fieldwork the ICDAS method was modified where dentists had access to cotton wool instead. Examinations were performed by two experienced and calibrated dentists, assisted by two researchers. No radiographs were taken and all examinations were performed in field conditions with materials and equipment as detailed in section 3.7.2.

3.8.2.1 Caries diagnosis criteria

The ICDAS visual scoring system was used to assess caries, restoration or missing tooth surfaces (Mesial [M], Occlusal [O], Distal [D], Buccal [B], Lingual [L] and Root [R]) of each of the 32 teeth. Where a surface was both restored and had caries it was coded as caries. Each surface was assessed independently. There are a total of 148 coronal surfaces since incisors and canines do not have occlusal surfaces.

The values recorded for coronal surfaces were in a 2 digit format [143] where:

- The first digit records caries (decay) experience on an ordinal scale. Possible values range from 0 to 6, where 0 is sound and 1 to 6 is caries present (higher score indicates more severe caries).
- The second digit records restorations (fillings) or sealants present as a categorical value.
- Additional to the above, two digit tertiary codes for missing surfaces was used e.g. 97 = missing due to caries.

The ICDAS scoring chart is shown in Appendix 9.5 and the included CRIB sheet gives a detailed description of scoring criteria and the corresponding codes adopted. At the point of creating an electronic database the two digit code was split into three variables for each tooth surface i) caries variable, ii) restoration variable, and iii) a missing variable.

3.8.2.2 Conversion of ICDAS data to DMF index

For the purposes of epidemiological reporting and meaningful statistical analyses, the ICDAS codes were converted to DMF scores at two levels differentiated by different degrees of decayed dentition. The Decayed (D) component was assessed as i) 'total obvious decay experience' (including white spot lesions), and ii) 'caries extending into dentine', where total caries experience included ICDAS caries codes 1 to 6 (D_1) inclusive, and caries extending into dentine was limited to the ICDAS codes 4 to 6 (D_3) inclusive. The Missing category was limited to ICDAS codes for loss of dentition due to caries and, for the Filled component, sealants were excluded. Table 3.2 summarises the codes used to compile each of the DMF outcome scores used in this thesis. For each respondent, the DMF data were first calculated at the surface level (D_1MFS and D_3MFS) and subsequently aggregated to tooth level (D_1MFT and D_3MFT) by scoring each tooth for presence of decay, missing, or filled dentition. Where a tooth was both decayed and filled it was recorded as decayed. This conversion was possible as ICDAS has been designed to be compatible with the DMF index (see Introductory chapter, page 6) [19].

Table 3.2 ICDAS codes used in the conversion to total obvious decay experience (D_1MF), caries into dentine (D_3MF), and severe caries (D_4MF)

ICDAS Codes	DMF Index		
Caries	**Decayed (D_1)**	**Decayed (D_3)**	**Decayed (D_4)**
0 – Sound	-	-	-
1 - First change in enamel	✓	-	-
2 - Distinct visual change in enamel	✓	-	-
3 - Enamel breakdown, no dentine visible	✓	-	-
4 - Underlying dentinal shadow	✓	✓	-
5 - Distinct cavity	✓	✓	✓
6 - Extensive distinct cavity	✓	✓	✓
Missing		**Missing (M)**	
92 – pontic placed for reasons other than caries	-	-	-
93 – pontic placed for carious reasons	✓	✓	✓
96 – surface cannot be examined, excluded	-	-	-
97 – tooth extracted as a result of caries	✓	✓	✓
98 – tooth missing for other reasons	-	-	-
99 – unerupted	-	-	-
P – implant	-	-	-
Restorations		**Filling (F)**	
0 – not sealed or restored	-	-	-
1 – sealant, partial	-	-	-
2 – sealant, full	-	-	-
3 – tooth coloured restoration	✓	✓	✓
4 – amalgam restoration	✓	✓	✓
5 – stainless steel crown	✓	✓	✓
6 – porcelain, gold, PFM crown or veneer	✓	✓	✓
7 – lost or broken restoration	✓	✓	✓
8 – temporary restoration	✓	✓	✓

3.8.2.3 Validation of summary scores: tooth vs surface level data

The following analyses were completed to ascertain which of the aggregate DMF continuous measures would be adopted as the outcome measures in the present study i.e. surface or tooth level data. To ensure no loss of data would result from adopting the tooth level scores the number of decayed surfaces (ICDAS caries codes 1-6) as a proportion of standing surfaces were compared against decayed teeth (ICDAS caries codes 1-6) as a proportion of standing teeth, where standing dentition was determined as any tooth not coded as missing (for any reason). The proportion of standing surfaces with caries were increasingly linearly correlated with the proportion of teeth with caries (see Figure 3.1) and a Spearman rank order correlation between these proportions confirmed this positive relationship ($r_s = 0.99$, $p < 0.001$). A robust regression of tooth scores explained 73% of the variation in surface level scores ($R^2 = 0.80$ without outlier). These findings suggest that the surfaces coded with caries were spread evenly across the dentition. It was therefore concluded decayed *teeth* was an acceptable measure for statistical analyses.

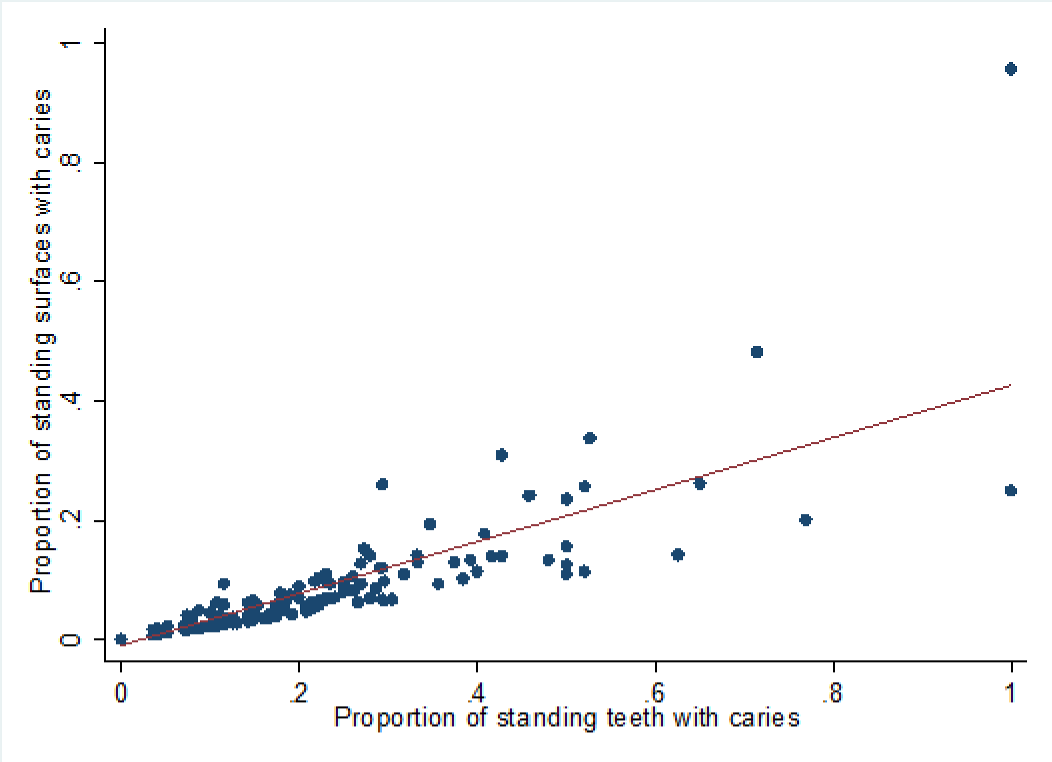

Figure 3.1 Proportion of standing coronal surfaces and teeth with caries

3.8.2.4 Justification for excluding third molars from summary scores

Not all individuals at age 16 years or older have erupted third molars (wisdom teeth) therefore in population surveys their inclusion in statistical tests can introduce a source of variability in datasets [150]. This variability would result in overestimation of caries experience when comparing those with carious third molars (i.e. all 32 teeth) to individuals with unerupted third molars, since the latter do not have dentition which would ordinarily contribute to the score. In this study population 12.5% (n = 37) had at least one un-erupted third molar (i.e. tooth 18, 28, 38 or 48 were coded as 99), with the number varying from 1 tooth (n = 27) to 3 teeth (n = 2).

Conversely, by excluding third molars there is the potential for underestimating disease experience since this dentition is characteristic of having deep pits and fissures on the biting surface and, being the furthest back, can, for some, present difficulties when toothbrushing, all of which are features which promote tooth susceptibility to caries.

When restricting the caries outcomes to the *four wisdom teeth alone*, the prevalence of both total decay experience (D_1MFT) and caries into dentine (D_3MFT) was approximately half among all prisoners, 54.7% and 49.3% respectively. The mean number of third molars affected was 1.51 (SD = 1.63) for D_1MFT with values ranging from 1 wisdom tooth (n = 36) to 4 wisdom teeth (n = 62) and, for D_3MFT, mean number of teeth affected was 1.08 (SD = 1.25) ranging from 1 (n = 41) to 3 (n = 70).

For this study, a decision was taken to exclude third molars in order to minimize the effect of variability in presence/absence of wisdom teeth. It must however be noted that by excluding this dentition the disease experience is underestimated for both total decay experience (D_1MFT) and caries extending into dentine (D_3MFT). Appendix 9.7.2, Appendix Table 9.2 illustrates how the distribution of both D_1MFT and D_3MFT scores varied in the study population when including and excluding third molars.

3.8.2.5 Assumptions of linear regression: distribution and homogeneity of variance (homoscedasticity)

Linear regression is one of the most commonly used methods for predictive analyses, within which ordinary least squares (OLS) is frequently adopted in the fields of medicine and psychology to develop a model where actual observations are closest to the predicted values. The use of such methods require certain assumptions to be met e.g. for OLS, variables must be: expressed as a linear relationship, have no extreme outliers, show constant variance (homoscedasticity), no multicollinearity, and the residual errors of the fitted line should be normally distributed [151].

The outcome measures were visually assessed for normality using kernel density plots and normal quantile plots. The Shapiro-Francia test was used as an overall test of departure from normality followed by two additional tests for skewness and kurtosis defined by D'Agostino and described in a manual produced by Indiana University [152]. Findings were similar for both D_1MFT and D_3MFT scores with significant departure from normality for all three tests ($p < 0.0001$). The histograms shown in Figure 3.2 illustrate the right skewed distributions for both outcome measures.

When modelling dental scores it was clear from plots of residuals against fitted values that the variance of the residuals increased with higher dental scores (Figure 3.3). This problem of heteroscedasticity has been reported by others [153] and violates one of the assumptions for ordinary least squares (OLS) methods. Transformations of the data (log, square-root) did not remove the skewness or the non-constant variance observed.

To overcome the issue of non-constant variance, robust regression methods were adopted to estimate relationships among variables for the present study. These robust methods are detailed in section 3.9.

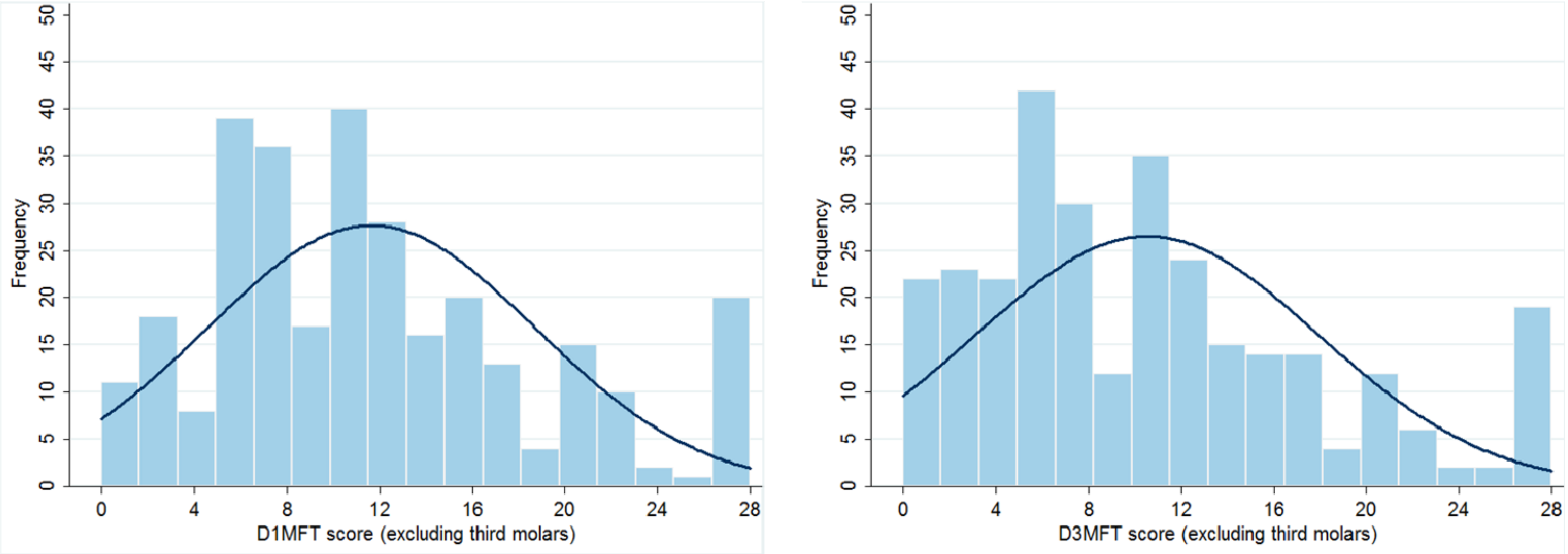

Figure 3.2 **Histograms of D_1MFT (left) and D_3MFT (right) scores[1]**

[1] Histograms are overlaid with normal distribution curve scaled to have the same mean and standard deviation as the plotted data

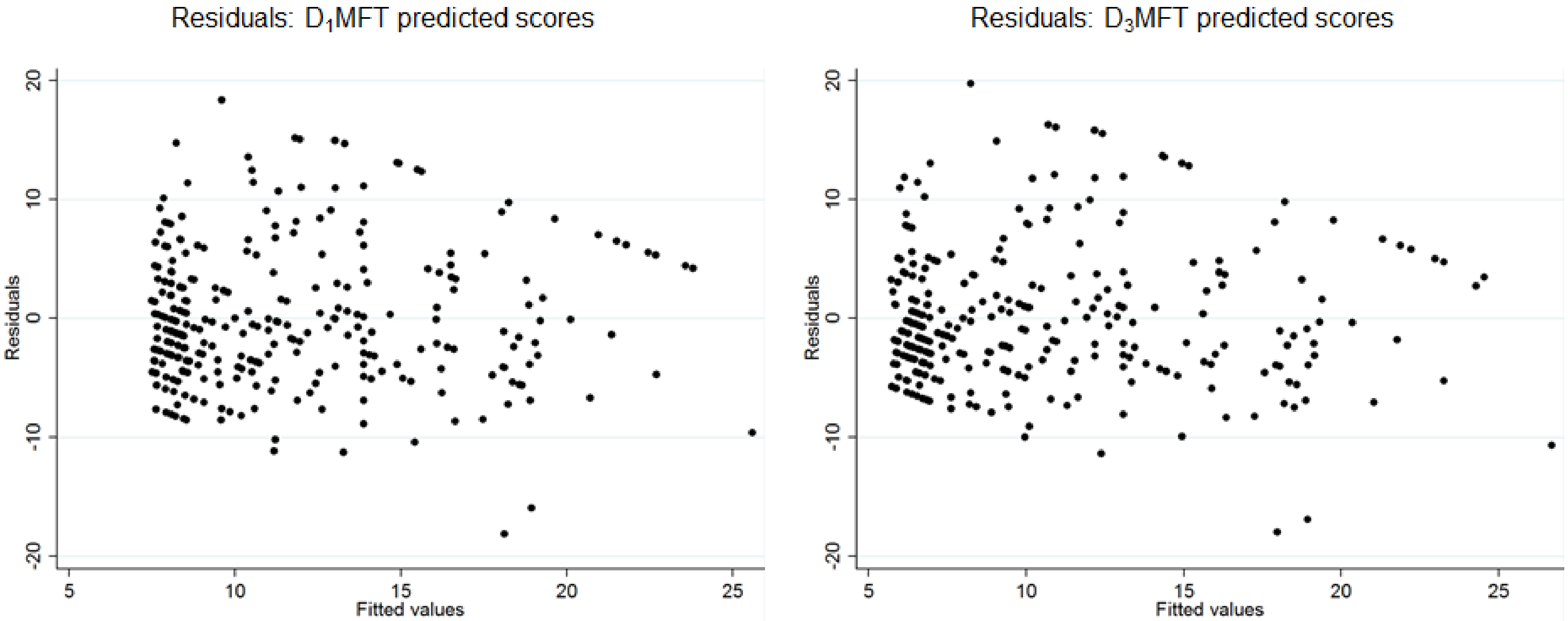

Figure 3.3 Plots of residuals against fitted values from age and gender adjusted robust regression models of D_1MFT (left) and D_3MFT (right) scores

3.9 Statistical analyses

The analyses for the present study was developed to address the following thesis objectives:

- To document prevalence of dental caries in the prison population of Scotland using data from a cross-sectional survey, conducted in 2011, which specifically included women, youth offenders, and long stay adult male prisoners.
- To document the prevalence of known risk indicators for dental caries and test for associations with caries cross-sectionally in the population of study.
- Explore the prevalence of other hypothesised risk indicators for caries and specifically test their association with caries in the population of study.
- Build a 'best' explanatory model, or models if data support different risk indicator experiences, in the sub-populations studied.

From the SOHIPP survey data available, the analyses specifically sought to explore how socio-demographics, social occupational position, education, family and living circumstances, prison experiences, health, indication of medicinal-related xerostomia, dental behaviours, dental attitudes, and psychosocial health (dental anxiety and depression) were related to dental caries experience. Dental caries was explored at two differing degrees of severity: [i] 'total (obvious) decay experience' which includes caries white spot lesions and enamel breakdown with no dentine visible (i.e. ICDAS caries codes 1, 2 and 3 in addition to ICDAS caries codes 4 to 6), and [ii] 'caries extending into dentine' which excludes ICDAS caries 1 to 3 and only includes ICDAS caries codes 4 to 6.

Before undertaking analyses, a detailed statistical analyses plan (see Appendix 9.8) was developed with supervision from the thesis supervisors (Ruth Freeman (RF), Andrew Hall (AH)). The subsequent statistical tests described below were run by TA with supervision from an experienced statistician (Shona Livingstone (SL)). The preceding description of work to organize the data collection, database and clean the survey data, and compute dental scores was completed by TA.

Survey results were electronically stored and descriptive statistics generated in IBM® Statistical Package for Social Sciences (SPSS®) (Versions 19.0 and 22.0) [144] for 64-bit edition Windows and, unless otherwise stated, all subsequent statistical analyses was performed using Stata/MP for Windows (Version 11.1) [154].

The analyses steps are summarized in Figure 3.4 and detailed in sequence below. In brief, descriptive analyses was first undertaken for all potential risk indicators and dental caries experience including the two outcome measures: total obvious decay experience (D_1MFT) and caries extending into dentine (D_3MFT) scores. As explained in section 3.8.2.4, third molars were excluded therefore each of the outcome scores ranged from 0 (no teeth decayed, missing due to caries, or filled) to 28 (all teeth either decayed, missing due to caries, or filled).

Subsequently, in steps 2 and 3 (see Figure 3.4) the association between each potential risk indicators and the D_1MFT and D_3MFT were calculated using both non-parametric and robust linear regression methods. The "univariable" regressions (step 3) were adjusted for age (each prison group), or age and gender (all prisons combined) and $p < 0.10$ was used to select potential risk indicators for further "multivariable" analyses (steps 5 and 6).

The "multivariable" analyses was undertaken to build models of the minimum set of risk indicators which explained the variance in D_1MFT and D_3MFT scores for all prisoners (step 5) and each of the three prison populations separately (step 6).

For all statistical tests *p*-values were from two-tailed significance tests and were unadjusted for multiple testing.

3.9.1 Descriptive statistics

Descriptive data were generated for caries experience including both caries outcome scores (total obvious decay experience and caries into dentine) in addition to all potential risk indicators to understand the prevalence and distribution of each measure. The data were assessed to ensure sufficient observations for further analyses and combined where possible. The results reported include percentages, means and standard deviations, and medians and 25^{th} and 75^{th} percentiles.

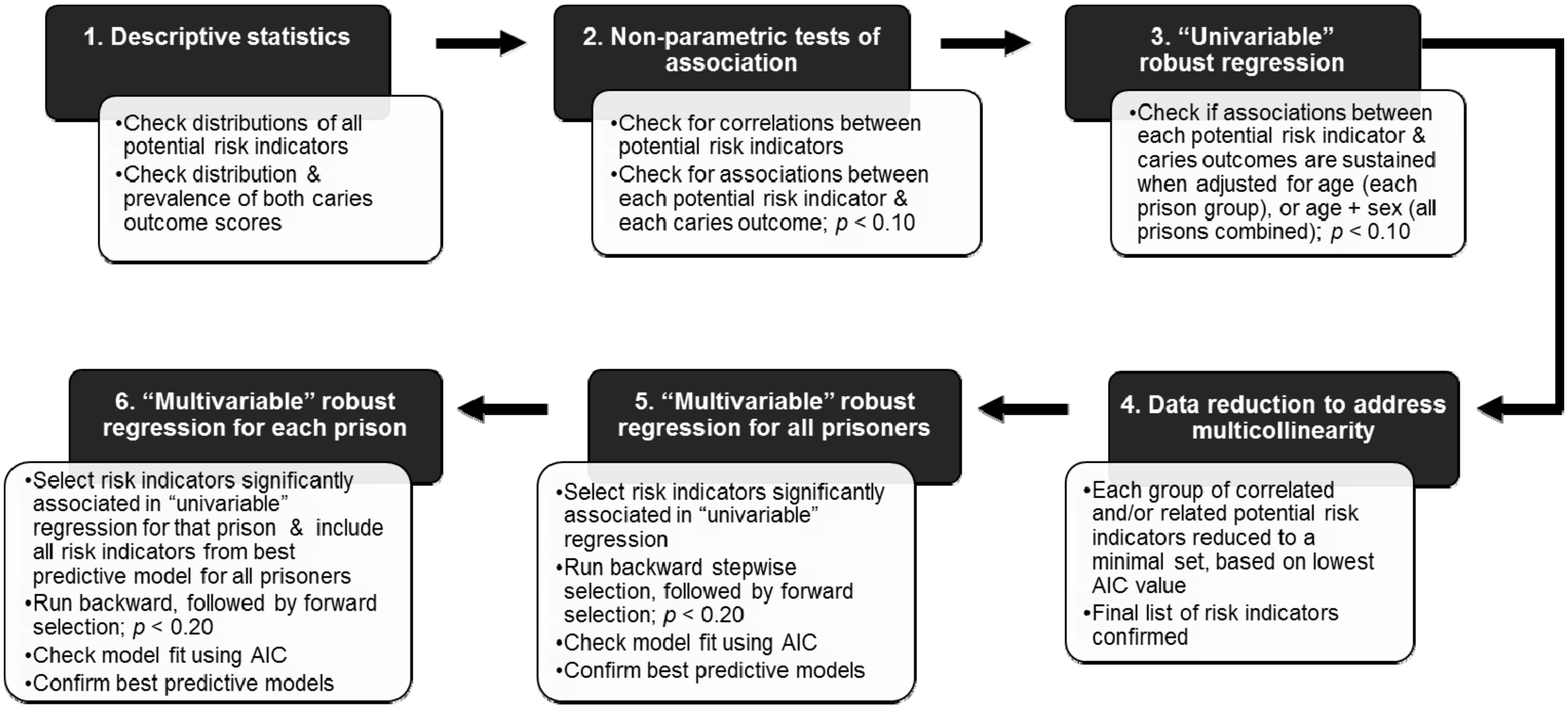

Figure 3.4 **Statistical strategy to develop models for D_1MFT and D_3MFT for all prisoners and each prison population**

Where relevant, the descriptives were supplemented with statistical tests to assess how potential risk indicators, or caries outcomes, varied by prison group, age and gender. The supplementary tests are specified in the results section.

Box plots were generated to show the distribution of continuous/ordinal measures by prison or other subgroups of interest. The box plots show the median (solid line) in a box bounded by the 25th and 75th percentiles. The whiskers on either side are the upper quartile plus 1.5 times, and the lower quartile minus 1.5 times, the interquartile range. Other standard illustrations were included, for example histograms and stacked barcharts, to illustrate distributions.

3.9.2 Non-parametric tests of association

In this study there were a large number of potential risk indicators (variables) under consideration for modeling; additionally each of the concepts under investigation (e.g. risk behaviours, dental attitudes) comprised multiple measures which by definition are related – these characteristics give rise to higher likelihood of intra-correlation (multicollinearity) among the variables. If *problematic* multicollinearity were to persist into the final model it would not be possible to report the coefficients with confidence as there would be too much overlap [155]. In the present study, correlational relationships, which may adversely affect regression modeling, were addressed at various steps. The first step was to identify such strongly correlated variables and subsequently related variables were further investigated in the data reduction step described separately below (see 4.9.3). The Spearman rank-order correlation coefficient (r_s) and its associated p-value [156] was calculated to identify pairs of continuous and/or binary variables that were strongly related. An r_s value of 0.80-1.0 was considered as 'very strong' and used alongside p-values of < 0.05 to describe strong correlations.

Kruskal Wallis and chi-square tests of independence were also calculated to identify associations between the remaining potential risk indicators. The Kruskal Wallis (unrelated) test (H) was used to assess whether mean ranks of an ordinal or continuous measure differ between categories of a categorical measure [156]. The H test was reviewed alongside summary statistics, e.g. means and medians, in order to interpret how the findings related to how the groups differed. The p-value is reported and values < 0.05 were used to confirm significant associations. A chi-square (χ^2) test of independence was used to compare a categorical with another categorical or binary variable, and associated p-values of < 0.05 were used to confirm relationships (degrees of freedom are reported in parenthesis). The χ^2 test assesses whether proportions of different levels of one variable vary with the levels of the second. Where one or more of the cells (e.g. individual prison analyses) had expected low frequencies (e.g. of five or less), the Fisher exact test was used instead.

To assess 'independent' relationships between dental caries outcome scores (continuous) and each of the potential risk indicators, standard non-parametric bivariate tests were first calculated followed by "univariable" robust regression models adjusted for age, and gender (see 3.9.4 below). The non-parametric tests varied depending on the potential risk indicator under investigation and included [156]: Spearman rank order correlation (r_s) to correlate ordinal/continuous variables [157], Wilcoxon rank sum for two independent samples (Mann-Whitney) test (Z) to compare dental scores by the binary variables [158, 159], and finally the Kruskal-Wallis test (H) to compare dental scores by variables with three or more groupings (categorical) [160]. For all three tests, p-values < 0.05 were taken as evidence of significant associations. Findings for these non-parametric tests are reported separately in the accompanying Appendix (see 9.9.1).

All of the non-parametric tests described here were calculated in IBM® SPSS® [144].

3.9.3 Data reduction to reduce multicollinearity

To reduce the influence of multicollinearity, where possible, related or correlated potential risk indicators were assessed and reduced to a minimal list. A series of robust regression models were fitted to D_1MFT scores including groups of correlated variables (section 3.9.2) or related variables (e.g. common measures of homelessness). The Akaike Information Criterion (AIC) was then used to decide which variable to remove from a set of correlated/related variables in an age, gender adjusted model to give a minimal set with the best model fit. The AIC is a goodness of fit measure that also accounts for model complexity; an improved model gives a **smaller** AIC value indicating the best compromise between higher percentage of the variation being explained and a more parsimonious model with fewer parameters [161]. The AIC is reported for the model with the full set and the model with the minimal set of variables within each group of variables being assessed.

3.9.4 "Univariable" analyses: associations between risk indicators and caries outcomes

Statistician (SL) guidance on suitable regression techniques was that: *"ordinary least squares (OLS) is reasonably robust to moderate departures from normality in the residuals, but heteroscedasticity in the residuals obviates the use of OLS, and whilst the coefficients remain unbiased, their associated standard errors and t-statistics are no longer valid. Ordinary OLS should therefore be replaced by an alternative method; in STATA there are two options for robust regression methods (i) the rreg command handles heteroscedasticity and outliers by using iteratively reweighted least squares to down-weight observations with higher variances and outliers with a large influence on the models (identified using Cook's D statistic), and (ii) the robust option of the regress command is a form of OLS, which also compares mean responses and produces the same point estimates of the beta coefficients for the explanatory variables, but computes robust standard errors using Huber-White sandwich estimators which give standard errors that are more conservative and less sensitive to outliers and importantly valid even when heteroscedasticity is an issue.[2, 3] The latter method makes use of the fact that the regression coefficients produced by the least-squares estimation are still unbiased even when there is the problem of non-constant variance, and uses a "sandwich estimate of the coefficient variances to correct the standard errors of the coefficient variances."[4] The latter method in (ii) using robust standard errors was chosen over the method in (i) as the choice of weights is not straightforward in this analysis[5] and difficult to agree upon."* In other words, the popular method for regression analyses – OLS – was not obviated by the non-normal distribution of the outcome scores. However, OLS methods operate by fitting a predictive line in the data where the observed dental score values in the dataset are closest to the corresponding predicted value on the fitted line. These distances between the fitted and observed values are the

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[2] Huber, Peter J. The behavior of maximum likelihood estimates under nonstandard conditions. Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability, Volume 1: Statistics, 221--233, University of California Press, Berkeley, Calif., 1967. http://projecteuclid.org/euclid.bsmsp/1200512988.

[3] White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica,* 48(4), 817-838. doi:1. Retrieved from http://www.jstor.org/stable/1912934 doi:1

[4] Fox J., Weisberg S. (2011) An R companion to Applied Regression, 2nd edition, Sage; p377, p184/5

[5] Williams, R. (2015, Jan 30). *Heteroskedasticity - University of Notre Dame*, Retrieved from http://www3.nd.edu/~rwilliam/

residuals and, in this dataset, these residuals tended to vary along the scoring range and are more scattered toward the left of the scoring range after adjusting for age (see section 3.8.2.5). For these reasons, in order to fit a predictive line which accounts for this changing variability, robust regression methods were used – the robust methods give less weight to larger residuals and thus give more reliable results.

Prior to running “multivariable” robust regression models, a “univariable” analysis was completed to assess the size of the relationship between each potential risk indicator and the dental outcomes when adjusted for age + gender (analyses of the whole population of study) and age alone (each of the three prison establishments). The results reported for each term of the model are similar to those from OLS, including an unstandardized beta coefficient (β) – size of effect, 95% Confidence Intervals (95% CI) for the coefficient and associated p-value, and are interpreted in exactly the same way. The size of effect estimates the mean value of the dental score for given levels of the risk indicator(s). The cut-off for significance in this preliminary analyses was $p < 0.10$ to decide which risk indicators to carry forward into the analyses that follow. For categorical variables, this p-value pertained to the overall test of all terms for that risk indicator. When interpreting the findings, p-values of < 0.05 were considered significant.

3.9.5 Multiple regression models for all prisoners

Step 5 of the analyses aimed to determine what combination of risk indicators would best predict each of the caries outcomes. The analyses began with a model of the outcome of interest, adjusted for age, gender and all risk indicators significantly associated with that outcome from the “univariable” regressions. This fitted model was limited to observations complete for all variables entered. For the backward and forward selection described below the observations were restricted throughout to these **same** observations at the start of the “multivariable” analyses.

Before proceeding with the stepwise regression, the Variance Inflation Factor (VIF) was first calculated to check for problematic multicollinearity, where values higher than 10 were considered problematic [155]. If multicollinearity were to be confirmed for further investigation, the test procedures reported in section 3.9.3 would be followed i.e. the AIC would be used to select from strongly related risk indicators.

Backward stepwise robust regression methods were then used to trim the variables (in order of highest *p*-value) to a minimal set most predictive of the outcome measure. A significance of $p < 0.20$ was the criterion adopted for excluding variables at each step, with the exception of age and gender which was retained throughout. Thus, at the end of this stepwise analyses, a list of risk indicators (including age and gender) was determined and these indicators had *p*-values ranging up to 0.20.

Next, forward stepwise selection methods were used to test if any variable removed in the process of backward selection now appeared significant ($p < 0.20$) when re-introduced. This analyses ensured each variable excluded in the backward selection was not significantly related however, it is important to note, where a variable was reintroduced, it did impact the *p*-values for the existing risk indicators modeled and in some cases resulted in *p*-values greater than 0.20.

To determine if the list could be reduced further, the AIC was then used to assess if removing any of the variables (other than age and gender) with *p*-values greater than 0.20 would improve model fit. An improved model was one with a smaller AIC value indicating best compromise between higher percentage of the variation being explained and a more parsimonious model with fewer parameters.

The most improved model from the AIC analyses was then run on the whole dataset i.e. **all** observations complete for the variables retained in the most improved model. The process of AIC analyses was repeated one more time to check if removing any variables would improve the model. The remaining risk indicators constituted the final best predictive model for the outcome under consideration.

The above analyses was repeated in full for both outcomes and the reported data includes the VIF, adjusted R^2, unstandardized β coefficients, 95% CI, and *p*-values for the initial model with all risk indicators entered and for the final model restricted to risk indicators which best predicted the caries outcome in this study population.

3.9.6 Multiple regression models for each prison population

Step 6 of the analyses aimed to determine what combination of risk indicators would best predict each of the caries outcomes but this time for *each* of the three prisoner populations surveyed i.e. female offenders, long-stay adult males, male young offenders.

The analyses undertaken followed the same method as already described in step 5 above – with one exception. In this regression the risk indicators entered into the first model included a) all risk indicators retained at end of the data reduction step that were also significantly associated with the outcome of interest in the "univariable" regressions *for that prison population*, **and** b) all risk indicators retained in the final model for the outcome of interest in the multiple robust regression for *all prisoners* (i.e. all risk indicators in the final model from step 3.9.5 above).

The VIF calculation, and backward, followed by forward, stepwise multiple regression models, and the AIC analyses were undertaken as described in section 3.9.5 above and *p*-values of less than 0.20 again determined which risk indicators were retained in the stepwise analyses. VIF, adjusted R^2, unstandardized β coefficients, 95% CI, and *p*-values were again computed. *P*-values of less than 0.05 denoted significant risk indicators in the final models. The remaining risk indicators above 0.05 but below 0.20 were retained because they improve the model and make estimates of the other effects more precise.

4 Results

4.1 Introduction

The chapter begins with a summary of the sampled sub-populations (females, male young offenders, long-stay adult males) including response rates, consent to examination and sample representativeness (see section 4.2). The remainder of the chapter is then divided into three parts:

Part 1 reports the descriptives beginning with all potential risk indicators (section 4.3), grouped by their themes: socio-demographics, family and living circumstances, health and indication of medicinal-related xerostomia, health risk behaviours, dental-related behaviours, dental-related attitudes, and psychosocial health. Part 1 concludes with the descriptive statistics for dental caries experience (section 4.4), including both caries outcome scores: total obvious decay experience (D_1MFT) and caries into dentine (D_3MFT) where D_1MFT includes white spot lesions and caries involving enamel breakdown whereas D_3MFT excludes these clinical presentations.

Part 2 reports (i) non-parametric tests of associations for the potential risk indicators, with each other (see section 4.5) and (ii) "univariable" robust linear regression models to test for associations between the potential risk indicators and each of the two dental outcome (D_1MFT and D_3MFT scores) (see section 4.6). This is followed by the data reduction analyses aimed at reducing the list of potential variables to be modeled so as to minimize influence of multicollinearity (section 4.7). Part 2 concludes with a final list of potential risk indicators to be modeled (see Table 4.17, page 152).

Part 3 reports the multiple regression models for the risk indicators which collectively best explained dental caries in the whole study population (section 4.8), and each of the surveyed prisoner populations i.e. females (section 4.9), long-stay adult males (section 4.10), and male young offenders (section 4.11).

4.2 Response rate and representativeness

A total of 342 prisoners consented to participate in the SOHIPP survey. Forty-four were not examined with 8 refusals; other reasons for non-examination included: attendance at court (n = 11), discharged/preparing to leave prison (n = 3), at work/education (n = 7), moved (n = 4) and agency visit (n = 2). An additional 9 prisoners could not be followed-up for unknown reasons.

A comparison of key characteristics between prisoners who were, and were not, examined indicated all but two (age and time imprisoned) did not significantly vary between the two groups (Table 4.1). Those not examined had spent significantly less time imprisoned and were younger. In the study dataset, age also had a moderate and positive relationship with time imprisoned among those who were examined (see Appendix Table 9.7). These findings are not unexpected since a shorter stay in prison could also result in less opportunity for examination as there was a time lag of approximately one day between survey questionnaires being dispensed and the examining teams being on site.

The data reported in the remainder of this study is limited to the respondents who were examined (n = 298) and, for brevity, are referred to as the whole study population or all prisoners. Findings for the full study sample, including those unexamined, are available from the SOHIPP report [70].

Table 4.1 Comparison of selected characteristics between examined and non-examined SOHIPP respondents

Characteristic	Un-examined *N* = 44	Examined *N* = 298		
	n (%)		OR* (95% CI)	*p*-value
Female	9 (20.5)	90 (30.2)	0.59 (0.27,1.29)	0.187
Have child(ren)	14 (38.9)	119 (48.8)	0.67 (0.33,1.37)	0.270
Ever homeless	24 (54.5)	121 (41.3)	1.71 (0.90,3.23)	0.101
Placed 'in care'	99 (36.0)	16 (37.2)	1.05 (0.54,2.05)	0.878
	Median (25th, 75th percentiles)		***Z*** **	***p*-value**
Age (years)	20.09 (19.35, 20.99)	25.27 (20.05, 36.20)	3.92	**<0.001**
Age left school (years)	15 (15, 16)	15 (15, 16)	1.61	0.112
Time imprisoned (years)	0.21 (0.05, 0.33)	0.83 (0.17, 2.69)	-96.61	**<0.001**
MDAS score (dental anxiety)	10 (6, 16)	8 (5, 13)	-1.65	0.100
CES-D score (depression)	13 (10, 28)	14 (10, 24)	-0.08	0.939

* Odds Ratio (OR) and unadjusted *p*-values obtained from logistic models of binary characteristics comparing unexamined to examined;
** Z statistic (*Z*) from two-sample Wilcoxon rank sum (Mann Whitney) test and unadjusted *p*-values

Part 1: Descriptive results

4.3 Potential risk indicators

4.3.1 Socio-demographics

The study sample comprised two hundred and ninety-eight examined participants with similar numbers recruited from the three prisons characteristic of females, male young offenders, and long stay adult males. Table 4.2 reports a summary of socio-demographics for each of the populations surveyed.

The mean ($\bar{x}$) age was 29.11 (SD = 11.22) years, ranging from 17.25 to 66.99 years; the median age (25th, 75th percentiles) was 25.27 (20.06, 36.20). By definition age differed by prison (Kruskal Wallis rank test, $H(2) = 169.89$, $p < 0.001$) and, as expected, the male young offenders were the youngest population studied ($\bar{x}$ = 19.67) and adult males the oldest ($\bar{x}$ = 36.23) (Table 4.2). As illustrated in Figure 4.1, few females were aged below 21 years (n = 16). Among those who were ≥ 21years of age (n = 74 females and n = 115 males), the mean age was 33.45 (SD = 10.15) for females and 35.44 (SD = 10.97) for males. A Kruskal-Wallis rank test showed no statistically significant difference in age between males and females when comparing those 21 years or older, $H(1) = 1.42$, $p = 0.234$), with a mean rank of 11362 and 6593 for males and females respectively.

Most respondents (95%) were of ‘White’ ethnicity. None of the other ethnicity categories were sufficiently populated to permit feasible or meaningful investigation of the effect of ethnicity in this study. Thus ethnicity was excluded from further analyses.

For attained education, the age respondents left education ranged from 7 to 21 years of age however the mode was 16 years (41%) with only 6% (n = 18) having left school *after* 16 years of age. For the purposes of meaningful analyses, using legislation in Scotland as a reference [146], the data were dichotomized into those who completed mandatory education of at least 16 years (n = 140), and ‘early school leavers’ aged under 16 years of age (n = 158). The proportions of prisoners who reached the minimum school leaving age did not differ by either prison (Pearson $\chi^2(2) = 0.75$, $p = 0.687$), or gender (Pearson $\chi^2(1) = 0.91$, $p = 0.341$), in those aged 21 years or older.

Table 4.2 Socio-demographics of study population by prison and gender

Characteristic	Females *N* = 90	Long-stay adult males *N* = 109	Male young offenders *N* = 99	All males *N* = 208	All prisoners *N* = 298
Prison	HMP&YOI Cornton Vale	HMP Shotts	HMYOI Polmont	HMP Shotts + HMYOI Polmont	All prisons
Age (*n*=298)					
Mean (*SD*)	30.89 (10.75)	36.23 (10.71)	19.67 (0.89)	28.35 (11.36)	29.11 (11.22)
Median (25th, 75th percentiles)	28.25 (22.54, 36.99)	36.20 (27.23, 43.52)	19.68 (18.97, 20.46)	21.99 (19.68, 36.20)	25.27 (20.06, 36.20)
Range	17.25-66.99	21.12-64.40	18.04-21.11	18.04-64.40	17.25-66.99
Gender (*n*=298)*					
Male	-	109 (100.0)	99 (100.0)	208 (100.0)	208 (69.8)
Female	90 (100.0)	0 (0.0)	0 (0.0)	-	90 (30.2)
Ethnicity (*n*=291)*					
White	79 (91.9)	105 (97.2)	93 (95.9)	198 (96.6)	277 (95.2)
Other	7 (8.1)	3 (2.8)	4 (4.1)	7 (3.4)	14 (4.8)
Attained education (*n*=298)*					
Early school leavers (< 16 yrs)	46 (51.1)	56 (51.4)	56 (56.6)	112 (53.8)	158 (53.0)
Completed mandatory education (≥ 16 yrs)	44 (48.9)	53 (48.6)	43 (43.4)	96 (46.2)	140 (47.0)
Unemployed (*n*=293)*					
Employed or In Education	19 (21.8)	41 (38.3)	30 (30.3)	71 (34.5)	90 (30.7)
Unemployed or Unable to work	66 (78.2)	66 (61.7)	69 (69.7)	135 (65.5)	198 (69.3)
Standard occupational classification (*n*=67)*					
Managerial & Professional	3 (16.7)	1 (3.6)	1 (4.8)	2 (4.1)	5 (7.5)
Intermediate	7 (38.9)	13 (46.4)	11 (52.4)	24 (49.0)	31 (46.3)
Routine & Manual	8 (44.4)	14 (50.0)	9 (42.9)	23 (46.9)	31 (46.3)
Living circumstances just prior to prison (*n*=292)*					
Stable (own property, rental, with family)	68 (78.2)	94 (87.0)	85 (87.6)	179 (87.3)	247 (84.6)
Non-stable (temporary, children's institute/home, homeless)	19 (21.8)	14 (13.0)	12 (12.4)	26 (12.7)	45 (15.4)
Marital status (*n*=281)*					
Single	69 (82.1)	74 (72.5)	88 (92.6)	162 (82.2)	231 (82.2)
Married/cohabiting	8 (9.5)	19 (18.6)	6 (6.3)	25 (12.7)	33 (11.7)
Separated/divorced/widowed	7 (8.3)	9 (8.8)	1 (1.1)	10 (5.1)	17 (6.0)
Shared residence with child(ren) (*n*=246)*					
Non-resident parent	16 (23.9)	28 (33.7)	13 (14.4)	41 (23.7)	57 (23.8)
Resident parent	19 (28.4)	34 (41.0)	5 (5.6)	39 (22.5)	58 (24.2)
No child	32 (47.8)	21 (25.3)	72 (80.0)	93 (53.8)	125 (52.1)

* Data are numerator (%); denominator vary due to missing values

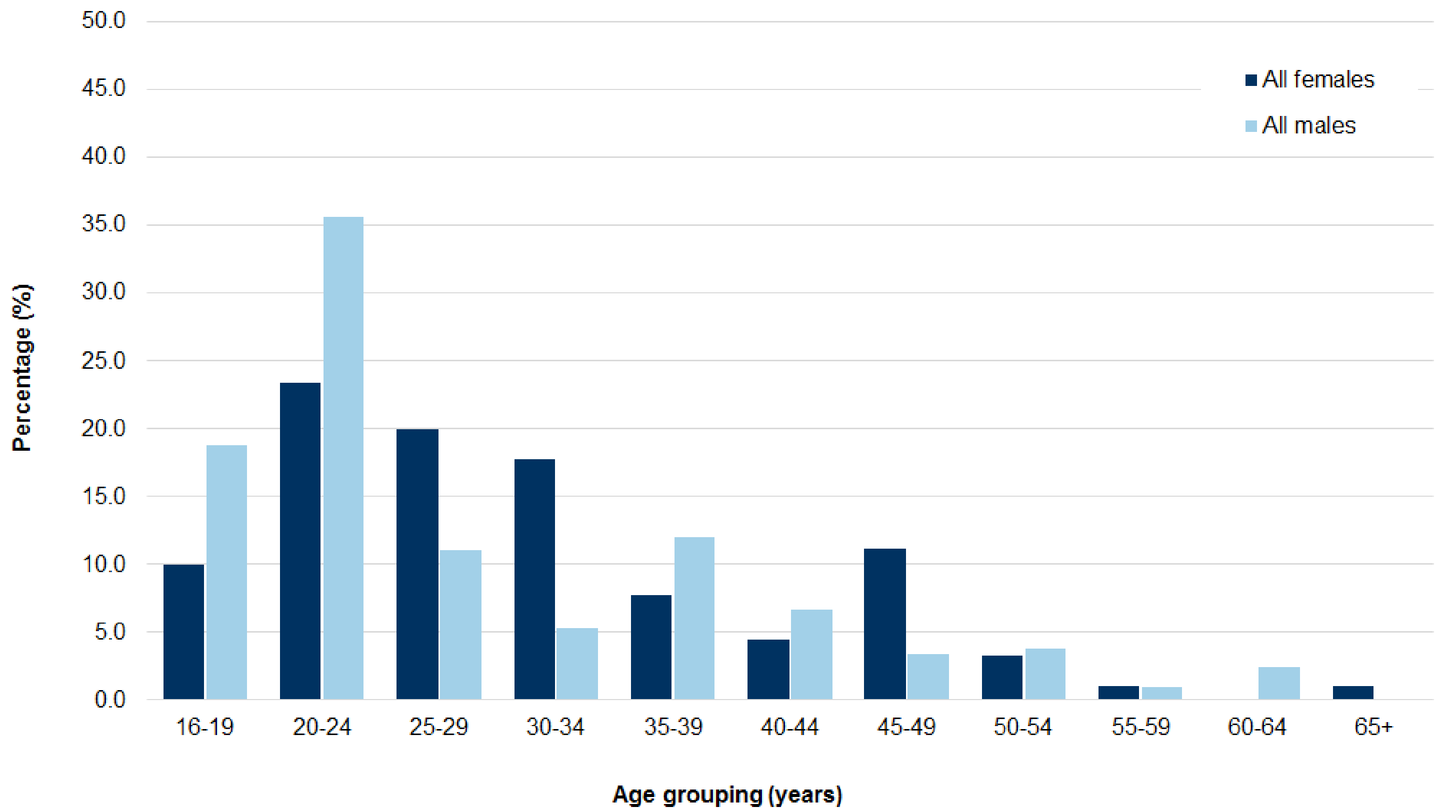

Figure 4.1 Age distribution of SOHIPP examined prisoners by gender, 2011[6]

[6] Figure for illustration only, age (years) was analysed as continuous measure

The responses for employment status just prior to imprisonment were grouped by those i) 'employed or in education' inclusive of casual work, and ii) those unemployed or unable to work ('unemployed'). Two thirds of respondents (n = 203) were unemployed just prior to imprisonment. Significantly larger proportions of females aged 21 years or older were unemployed when compared with males (82% compared to 61% of males) (Pearson $\chi^2(1) = 9.00$, $p = 0.003$). Concurrent with the gender/prison profile of this study population (see Table 4.2) a significant difference by prison was also determined ($\chi^2(2) = 6.13$, $p = 0.047$).

Of the respondents who were employed, training or doing casual work, sixty-seven (74%) provided a job title that could be grouped into a standard occupational classification (SOC) [147]. Equal proportions (46%) were classified as working in 'Intermediate' and 'Routine & Manual' occupations; by comparison, few participants (8%) were in 'Managerial & Professional' occupations. Table 4.2 illustrates the limited observations among the separate populations. Amongst adults ($\geq$ 21 years of age), observations for SOC were limited to n = 42 although the proportions were similar: (45%) for 'Intermediate' and 'Routine & Manual' with few (10%) in 'Managerial & Professional' occupations. There was no evidence for a difference between adult females and males in prevalence of the different SOC categories (Fisher's exact $p = 0.111$).

More than four fifths of the sample (82%) were single, 12% (n = 33) were married or cohabiting, and 6% (n = 17) were separated, divorced or widowed. Marital status significantly differed by prison (Pearson $\chi^2(4) = 15.21$, $p = 0.004$) and male young offenders were the least likely to be married or cohabiting when compared to the other prisons; as shown in Table 4.2 these offenders were also younger in age when compared to the female and adult male populations surveyed. When comparing adult males and females (21 years of age or older), there was no significant difference ($\chi^2(2) = 1.74$, $p = 0.419$) in marital status.

A fifth of participants (n = 48) provided no information about their parental experiences. Amongst the remaining 250 respondents, half (n = 125) had children with similar proportions reported by males (48%) and females (54%). Most parents also provided information about their childrens' living circumstances (n = 115); of these half

(n = 58) reported their children were living with them prior to their incarceration. For the purposes of analyses the information for having children and shared residence were combined into a single variable grouped by: (i) non-resident parent, (ii) resident parent, and (iii) had no child; see Table 4.2.

The number of children varied between one and seven, although higher proportions of parents providing this information had either a single child (48%), or two children (29%). Since few prisoners (n = 9) had four or more children it was not feasible to assess the effect of having multiple children which may be informative about the impact of, for example, different lifestyle choices.

Almost all respondents (n = 294) detailed their living accommodation just prior to imprisonment and 37% lived with parents or family, 32% rented, and 16% owned their own property; these were categorized as 'stable' accommodation. The remaining groups (bed & breakfast, children's institute or home, temporary accommodation or homeless), were categorized as 'non-stable'. Although the observed proportion living in a non-stable accommodation was higher amongst females (22%) when compared with adult males (13%) or male young offenders (12%), the stable nature of living circumstances just prior to prison did not significantly vary by prison (Pearson $\chi^2(2)$ = 3.94, p = 0.139).

Two fifths (n = 121) of examined prisoners stated they had experienced homelessness and there was a striking pattern by gender with higher proportions of females reporting homelessness (60% vs 33% of males). A logistic regression among adults (aged 21 years or older) determined that female offenders were 2 times more likely to have experienced homelessness when compared with males (unadjusted OR = 2.40 (95% CI 1.31, 4.37), p = 0.004). This finding persisted even after adjusting for age (adjusted OR = 2.30 (95% CI 1.25, 4.22), p = 0.007).

Among those who had been homeless, higher proportions of females had experienced homelessness for periods of 1 year or longer (44%), when compared with adult males (34%) or male young offenders (28%); Figure 4.2 illustrates the different durations experienced by the numbers reporting homelessness in each prison. Association of gender in the *total* population showed no statistical difference between females and males for length of time of homelessness experienced (Spearman rank order correlation

$r_s = 0.16$, $p = 0.145$) (Appendix 9.9.1); however the same test repeated among adults (≥ 21 years of age) showed females had experienced longer periods of homelessness when compared with males ($r_s = 0.234$, $p = 0.001$).

Responses for living circumstances as a child or teenager indicated a third (n = 99) had been placed ‘in care’ (children’s institute or foster care). History of being placed in care was equivalent (Pearson $\chi^2(2) = 4.45$, $p = 0.108$) across each of the three prisons (35%, 30%, 44% in females, adult males, and young offenders respectively) and (among adults) between males (31%) and females (31%) ($\chi^2(1) = 0.005$, $p = 0.944$).

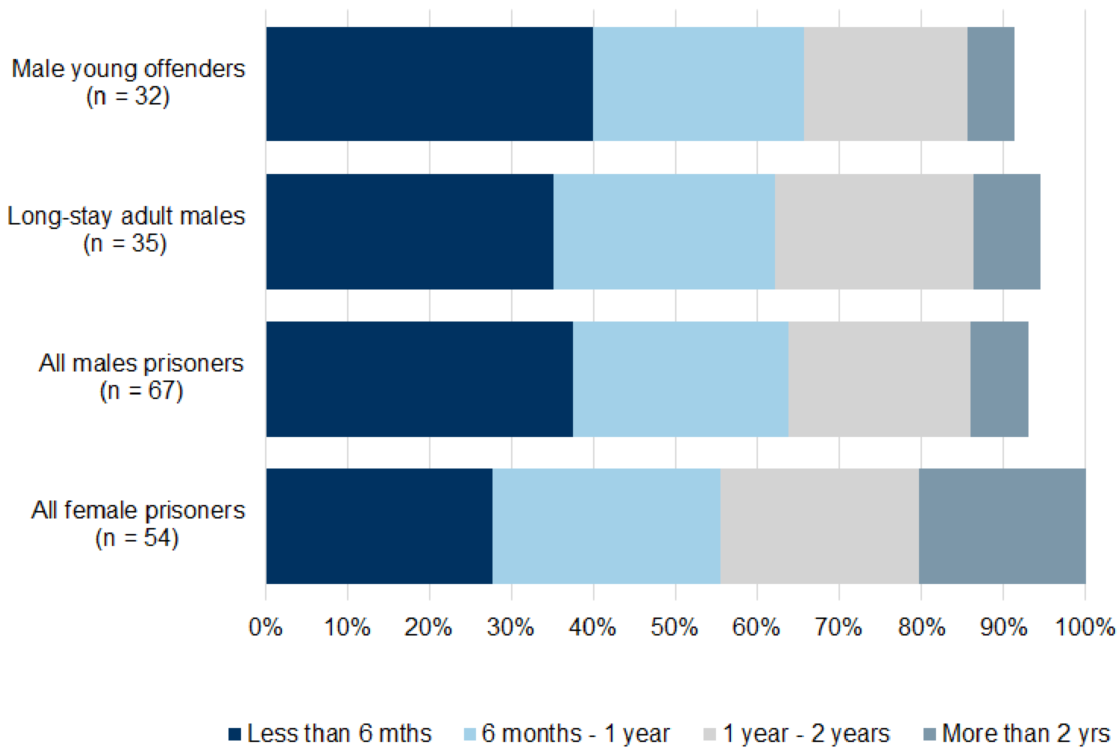

Figure 4.2 Length of homelessness experienced by those ever homeless, by prison and gender[7]

[7] Percentages do not total 100 due to missing observations; n = 2 adult males; n = 3 male young offenders

Respondents were asked about the length of time they had been in prison, their current sentence length, and history of prison remands and sentences. Each of these are described in detail below and Table 4.3 shows a breakdown of prison experiences by the populations surveyed.

Twelve individuals had no prior experience of the prison setting whereas most (93.7%) had a history of being remanded ($\bar{x}$ remands = 4.50, *SD* = 6.53) or held for a sentenced imprisonment ($\bar{x}$ sentences = 3.37, *SD* = 6.40).

At time of survey, participants had on average been imprisoned for 2.55 years (*SD* = 5.03) with eighty-seven (29%) incarcerated for more than 2 years, and 17 (6%) imprisoned for more than 10 years.

Similar proportions were in prison for a short-term period of less than 4 years (47%) as those serving sentences of more than 4 years (46%).

Given the unique characteristics of the three prisons, as expected the prison experiences described above varied by prison (see Table 4.3). Nearly all (74%) prisoners recruited from HMP Shotts were serving long-term sentences of more than 4 years and these prisoners also had significantly higher numbers of previous stays in prison (sentences and remands).

Table 4.3 Comparison of prison experience measures by prison

Characteristic	Females *N* = 90	Long-stay adult males *N* = 109	Male young offenders *N* = 99	Kruskal-Wallis *H* (*df*)	*p*-value
Number of remands					
Observations *n* (%)	67 (74.4)	82 (75.2)	94 (94.9)	17.4 (2)	**<0.001**
Mean (*SD*)	2.58 (3.24)	6.68 (9.23)	3.96 (4.69)		
Median (25^{th}, 75^{th} percentiles)	1 (1.00, 3.00)	3 (1.00, 9.25)	2 (1.00, 5.00)		
Number of sentences					
Observations *n* (%)	55 (61.1)	88 (80.7)	72 (72.7	14.0 (2)	**0.001**
Mean (*SD*)	1.95 (3.01)	5.20 (9.26)	2.22 (2.07)		
Median (25^{th}, 75^{th} percentiles)	1 (1.00, 2.00)	2 (1.00, 5.00)	1 (1.00, 3.00)		
Time imprisoned (years)					
Observations *n* (%)	75 (83.3)	106 (97.2)	92 (92.9)	117.7 (2)	**<0.001**
Mean (*SD*)	2.27 (6.13)	4.44 (5.45)	0.58 (1.64)		
Median (25^{th}, 75^{th} percentiles)	0.29 (0.06, 1.43)	2.65 (1.41, 4.94)	0.19 (0.08, 0.48)		
Range	0.00-46.67	0.17-34.38	0.00-15.23		
				χ*² (*df*)	***p*-value**
Sentence length – *n* (%)					
Less than 4 years	63 (70.0)	4 (3.7)	73 (73.7)	147.8 (2)	**<0.001**
More than 4 years	21 (23.3)	100 (91.7)	15 (15.2)		

* Pearson's chi-squared test

4.3.2 Health conditions and medicinal-related xerostomia indicated

One hundred and thirty-five participants (52%) presented with one or more of the health conditions known to share common risk factors with dental caries. When explored by prison establishment, the prevalence of these health conditions varied by 63% (n = 52) in the female prison, 52% (n = 49) for adult male offenders, and 41% (n = 34) of male young offenders.

One hundred and thirty-two (44%) individuals were taking prescribed medicines of which n = 119 detailed what these were. By cross-referencing with the BNF, it was possible to discern 65% were taking at least one medicine with dry mouth potentially indicated as a side effect. As shown in Figure 4.3, an indication of medicinal related dry mouth differed by prison (Pearson $\chi^2(2) = 32.79$, $p < 0.001$) with dry mouth potentially indicated for higher proportions of females (41%), when compared adult males (31%) and male young offenders (6%). In the adult population (aged 21 years or older), a logistic regression determined females were 1.87 times more likely to have medicinal-related dry mouth indicated, when compared with males (unadjusted OR 1.87 (95% CI 1.02, 3.41), $p = 0.043$; age adjusted OR 1.91 (95% CI 1.04, 3.51), $p = 0.037$).

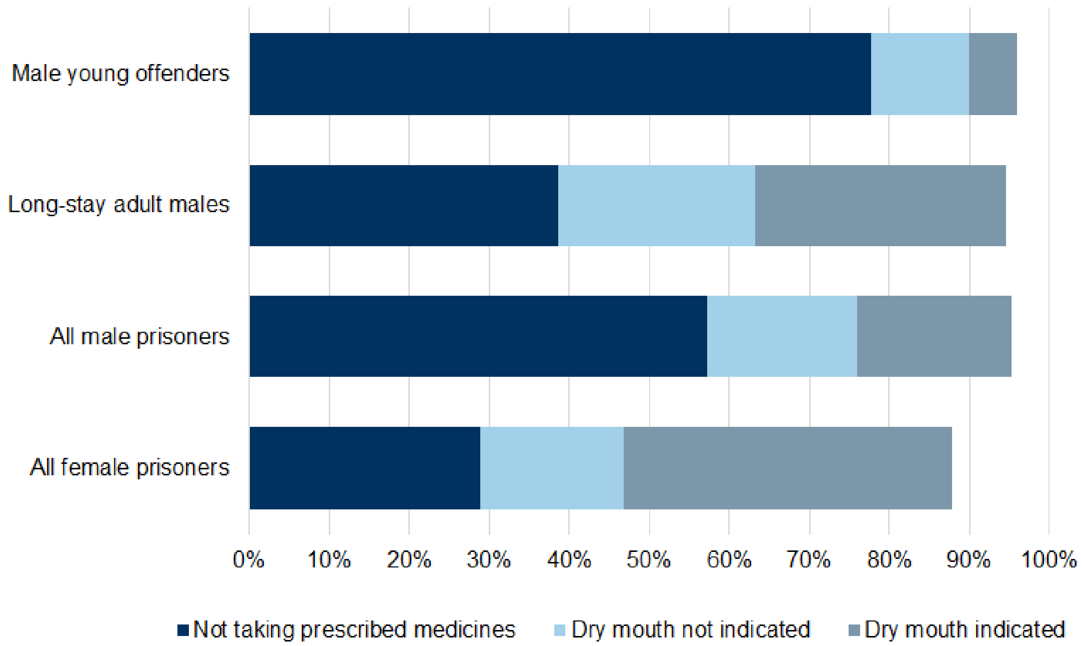

Figure 4.3 Indication of medicinal-related xerostomia by prison and gender[8]

[8] Percentages do not total 100 due to missing, 'Don't know' or 'Prefer not to say' responses for prescribed medicines; n = 11 females, n = 6 adult males, n = 4 male young offenders

4.3.3 Health risk behaviours

Three quarters (n = 224) of the study population smoked cigarettes with high proportions of smokers reported in all three prisons: 74% of females, 71% of adult males, and 81% of male young offenders. By comparison, only 4 individuals chewed tobacco of which 3 did not smoke cigarettes, thus in this study only cigarette smoking is considered in the regression analyses. The proportion of prisoners who smoked cigarettes did not differ by prison (Pearson $\chi^2(2) = 2.74$, $p = 0.254$), or gender where ≥ 21 years of age (Pearson $\chi^2(1) = 1.27$, $p = 0.259$).

Among the smokers, the number of cigarettes smoked varied between 2 and 50, however 94% smoked 10 or more cigarettes each day and 50% of individuals, in all three prisons surveyed, smoked at least 15 cigarettes per day.

Seventy-seven percent (n = 230) of participants stated they had used (illegal) drugs with high proportions observed across all three prisons: 66% (n = 59) of females, 75% (n = 82) of adult males, and 90% (n = 89) of male young offenders.

In contrast to the highly prevalent smoking and drug use behaviours, fewer prisoners had used intravenous drugs (n = 50), or had taken part in a drug rehabilitation programme (n = 57); as illustrated in Figure 4.4 this pattern was sustained for each population surveyed.

As indicated by those taking part in rehabilitation, higher proportions of females (30%) had a history of substance misuse when compared with adult males (22%) and male young offenders (7%). This was supported by a statistically significant difference by prison (Pearson $\chi^2(2) = 16.05$, $p < 0.001$); however when the analysis was repeated by gender amongst adults (≥ 21 years of age) there was no significant difference (Pearson $\chi^2(1) = 2.66$, $p = 0.103$) between proportions of males (21%) and females (32%).

Prevalence of intravenous drug use (IDU) also differed by prison (Pearson $\chi^2(2) = 25.85$, $p < 0.001$), with 33% females, 19% in adult males, and 3% of young offenders self-reporting IDU. Among adults (≥ 21 years of age), there was some evidence for significantly higher proportions of females (32%) using intravenous drugs when compared with males (19%) (Pearson $\chi^2(1) = 3.90$, $p = 0.048$).

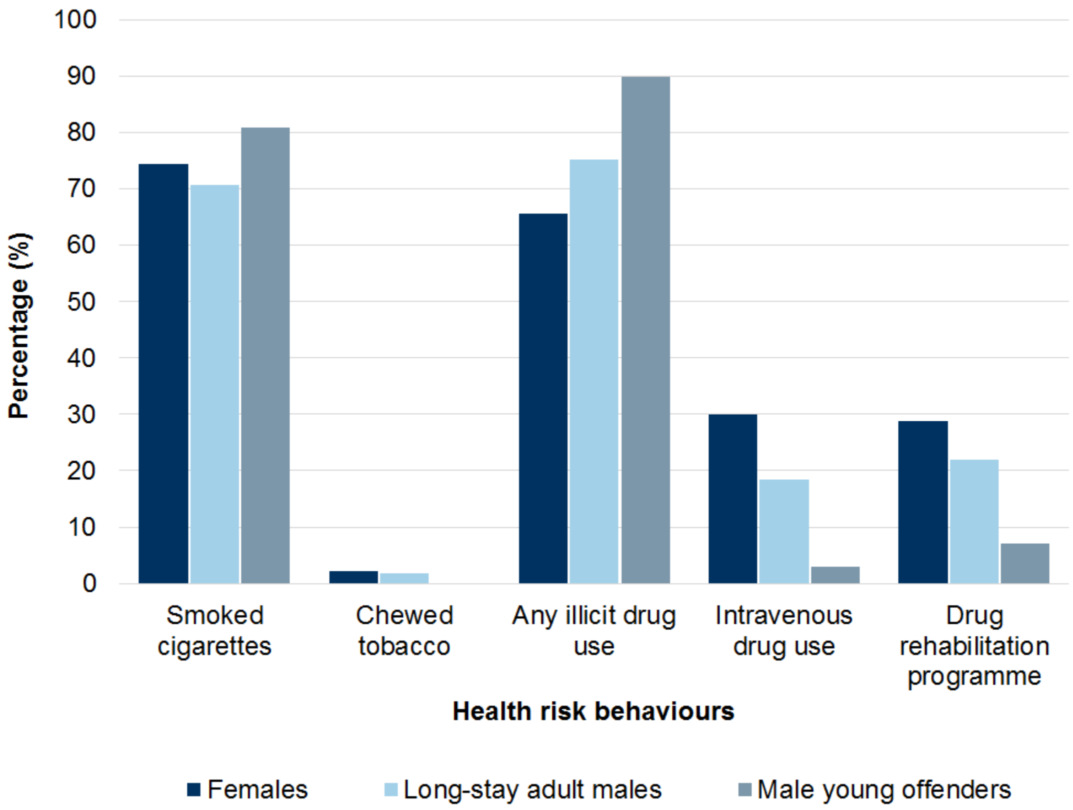

Figure 4.4 Health risk behaviours reported by prison

4.3.4 Dental health-related behaviours

Half of examined participants (n = 148) reported they had ever attended the prison dentist with a significant difference by prison (Pearson $\chi^2(2) = 36.78$, $p < 0.001$) where higher proportions of adult males attended (72%) when compared with females (45%) and male young offenders (31%). Whilst a logistic regression confirmed long-stay adult males were 3 times more likely to attend the prison dentist when compared with females, this relationship could be explained by having spent more time in prison and the relationship between prison establishment and seeing a prison dentist disappeared after adjusting for time imprisoned (p = 0.543 in logistic regression of prison dentist against time in prison and prison establishment, Table 4.4).

Table 4.4 Logistic regression examining prison dental attendance between prisons, adjusted for time imprisoned

	Unadjusted model		Adjusted model*	
	OR (95% CI)**	*p*-value	OR (95% CI)**	*p*-value
Population		**<0.0001**		0.543
Females	1.0		1.0	
Long-stay adult males	3.12 (1.72, 5.65)	**<0.001**	0.78 (0.33, 1.83)	0.564
Male young offenders	0.53 (0.29, 0.97)	0.038	0.67 (0.33, 1.36)	0.271
Time imprisoned (years)	-	-	2.36 (1.66, 3.35)	**<0.001**

* Adjusted for time imprisoned (years); ** Odds Ratio (OR) 95% Confidence Intervals (95% CI)

Dental attendance was also assessed by preventive dental treatments received and time since last dental visit. Just over half (n = 166) of all prisoners had attended for a preventive dental treatment (scale and polish, fissure sealant, and/or fluoride treatment), and the proportions by prison were 63% of females, 60% of adult males, and 44% of male young offenders. Whilst high proportions (74.7%) had reportedly seen a dentist within the last 24 months, under-utilization of dental services was also evident with 23.5% reportedly last seeing a dentist *more than* 2 years prior to survey and 5 prisoners (almost 2%) having never attended. There was no significant difference in the dental attendance between the prisons as measured by the mean ranks (Kruskal Wallis rank $H(2) = 2.82$, $p = 0.244$).

Two daily dental behaviour measures were assessed: toothbrushing with fluoride toothpaste and avoiding sugar consumption between meals. Both these dental behaviours were improved in the prison setting where 16% (n = 48) more prisoners brushed their teeth and 6% (n = 19) more avoided sugars in-between meals when compared to their home environment outside of the prison establishment. The proportions, for each behaviour, and in the home and prison setting, for each population of study are shown in Figure 4.5. McNemar tests [155] were performed for each population to determine if these behaviours differed significantly between the two environments (see Table 4.5). Toothbrushing was significantly improved in the prison setting for adult males and young offenders, but change in sugar consumption was only significant for adult males.

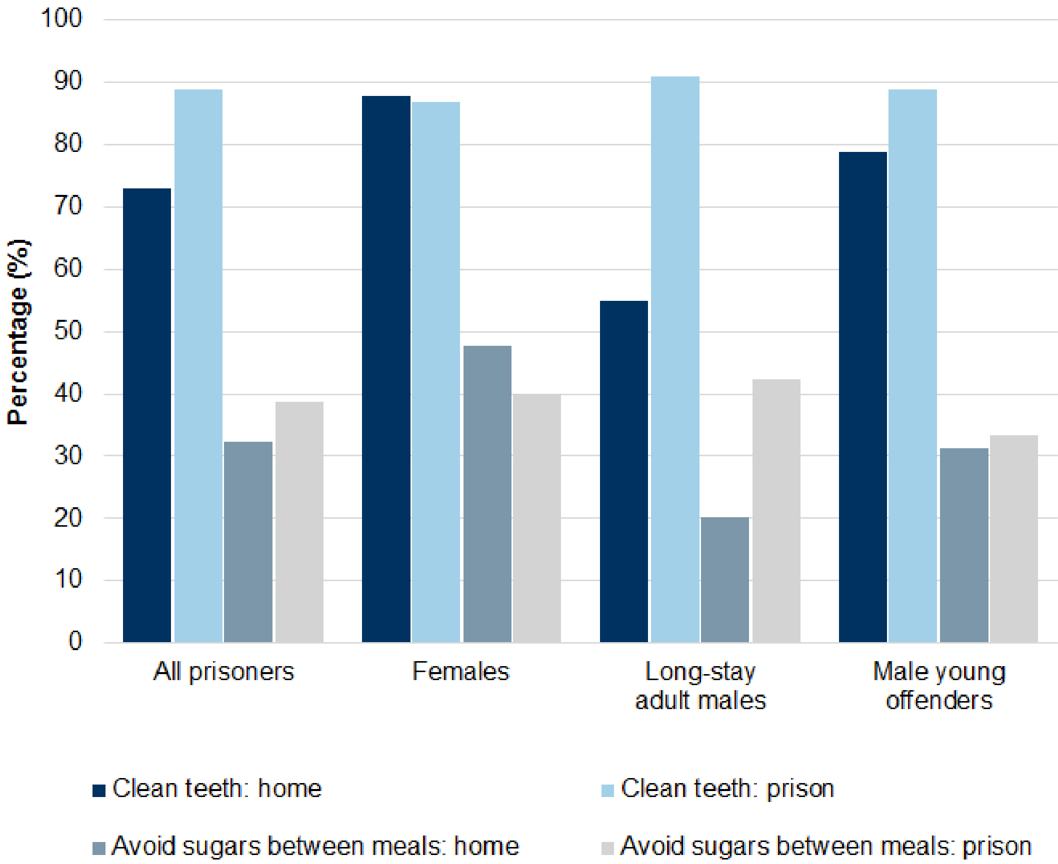

Figure 4.5 **Daily dental behaviours, between home and prison, by prison**

Table 4.5 **Within-person comparison of toothbrushing and sugar consumption behaviours between home and prison settings**

	Brush teeth with fluoride toothpaste		Avoid sugars between meals	
	χ^2 (*df*)	*p*-value	χ^2 (*df*)	*p*-value
Females	0.05 (1)	0.819	2.13 (1)	0.144
Long-stay adult males	33.80 (1)	**<0.0001**	15.16 (1)	**0.0001**
Male young offenders	4.17 (1)	**0.041**	0.13 (1)	0.724

McNemar's χ^2 (degrees of freedom)

4.3.5 Dental health-related attitudes

For their most recent dental visit, almost two thirds (67%) indicated that pain, discomfort, or trouble with their teeth had prompted their attendance; a quarter (25%) had attended for a routine dental check-up, and 8% for 'other' reasons. This pattern of attendance was observed for all three prison populations (Table 4.6). When comparing responses for check-up and difficulties with teeth as the reason for last attendance, those attending for a check-up were typically older among the adult male and female populations. A logistic regression showed (amongst those ≥ 21 years of age) females were almost three times more likely to attend for a check-up when compared with males (unadjusted OR 2.55 (95% CI 1.16, 5.59), $p = 0.020$; adjusted for age OR 2.85 (95% CI 1.27, 6.42), $p = 0.011$).

Responses for treatment preferences indicated most prisoners, from all three prisons, preferred dental treatment in the form of crowns (front tooth) or fillings (back tooth) rather than extraction (see Table 4.6 for exact numbers). For back teeth, whilst higher proportions of male young offenders (77%) were observed to prefer restorative treatment when compared with adult males (72%) and females (61%), this was not statistically different (Pearson $\chi^2(2) = 5.92$, $p = 0.052$). There was even less evidence for a difference in treatment preferences for front teeth between the prisons with 87% females, 89% adult males and 88% male young offenders preferring treatments (Pearson $\chi^2(2) = 0.23$, $p = 0.890$).

Table 4.6 Dental health-related attitudes by prison

Characteristic	Females *N* = 90	Long-stay adult males *N* = 109	Male young offenders *N* = 99	All prisoners *N* = 298
Reason for last dental attendance*'**				
Check-up	26 (37.7)	16 (16.7)	18 (24.0)	60 (25.0)
Trouble with teeth or gums	40 (58.0)	77 (80.2)	44 (58.7)	161 (67.1)
Other reason	3 (4.3)	3 (3.1)	13 (17.3)	19 (7.9)
Treatment preferences: aching back tooth*				
Fillings	50 (61.0)	78 (72.2)	75 (77.3)	203 (70.7)
Extraction	32 (39.0)	30 (27.8)	22 (22.7)	84 (29.3)
Treatment preferences: front tooth requiring extraction*				
Crowns	71 (86.6)	95 (88.8)	84 (88.4)	250 (88.0)
Extraction	11 (13.4)	12 (11.2)	11 (11.6)	34 (12.0)

* Data reported are *n* (%); ** Responses 'Can't remember' are treated as missing

4.3.6 Psychosocial health

The mean Modified Dental Anxiety Scale (MDAS) score (possible range 5 to 25) for 284 examined participants was 10.06 (SD = 5.61) with a median of 8 (5, 13). Thirty-three participants scored 19 or over and thus 12% of this study population were categorised as dentally phobic. Larger proportions of examined participants reported that they were extremely anxious about having their teeth drilled (12%) and having a local anaesthetic (14%). The least feared item was a scale and polish with only 4% stating they were extremely anxious. The MDAS scores are reported for each prison population in Table 4.7.

The distribution of MDAS scores were highly skewed to the right (see Figure 4.6) thus it was more sensible to compare median scores. Therefore, a median regression was performed to model median MDAS scores across prisons using the adult males as the reference group (qreg (quantile) command in STATA) [162]. The median MDAS score was 3 units higher in females, when compared to adult males (unadjusted β = 3.0 (95% CI 0.4, 5.6), p = 0.023) however median scores for male young offenders did not significantly differ (unadjusted β = 1 (95% CI -1.4, 3.4), p = 0.421). The significant difference between females and adult males was sustained when adjusted for age (β = 3.0 (95% CI 0.3, 5.7), p = 0.032).

The Center for Epidemiologic Studies Depression (CES-D) scale (possible range 0 to 60) was completed by 236 examined prisoners. Of these, 105 (45%) scored at least 16, which suggested they were suffering from a depressive illness. The mean score for depression was 17.69 (SD = 11.73) and the median 14 (10, 24). The median CES-D scores were again compared across prisons using the adult male prison as the reference. Again, median scores between females and adult males significantly differed where the median score for females was 8 units higher (unadjusted $\beta = 8$ (95% CI 5.4, 10.6), $p < 0.001$). This difference was sustained in a multivariate quantile regression adjusted for age among adults (≥ 21 years of age) ($\beta = 8$ (95% CI 6.6, 9.4), $p < 0.001$). There was no evidence for a difference between male young offenders and adult males ($p > 0.9$).

Table 4.7 Psychosocial health scores by prison

Characteristic	Females *N* = 90	Long-stay adult males *N* = 109	Male young offenders *N* = 99
Dental anxiety (MDAS)			
Observations *n* (%)	82 (91.1)	104 (95.4)	98 (99.0)
Mean (*SD*)	11.84 (6.52)	9.12 (4.90)	9.56 (5.12)
Median (25^{th}, 75^{th} percentiles)	10 (6, 17)	7 (5, 11)	8 (5, 12)
Range	5-25	5-25	5-25
Highly dentally anxious*	16 (19.5)	7 (6.7)	10 (10.2)
Depression (CES-D)			
Observations *n (%)*	67 (74.4)	87 (79.8)	82 (82.8)
Mean (*SD*)	22.27 (11.30)	14.52 (10.25)	17.30 (12.46)
Median (25^{th}, 75^{th} percentiles)	20 (13, 30)	12 (8, 20)	12 (9, 25)
Range	1-51	0-55	0-52
Depression indicated**	44 (65.7)	31 (35.6)	30 (36.6)

* *n* (%) individuals scored MDAS ≥ 19; ** *n* (%) individuals scored CES-D ≥ 16

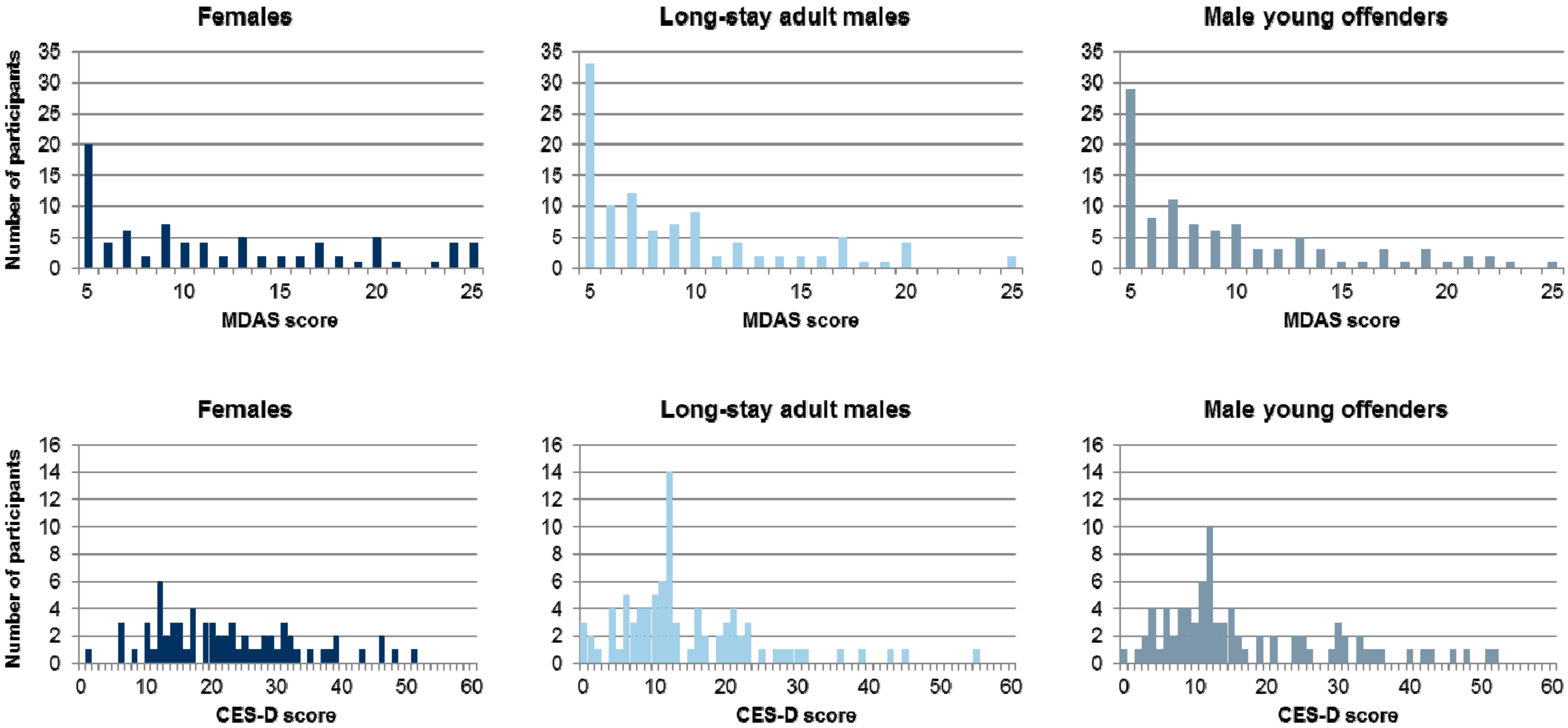

Figure 4.6 **Frequency distribution of psychosocial health scores by prison**

Summary of potential risk indicators

- 298 prisoners were examined with equal proportions of women, male young offenders, and adult males. 93% were of 'White' ethnicity and the mean age was 29.11 years.
- Half (53%) did not complete compulsory education of 16 years as legislated in Scotland.
- Two thirds (69%) were unemployed just prior to imprisonment and, among adults, female unemployment was higher (82%) when compared to males (61%).
- High proportions (82%) were single, 12% were married or with a partner, and few (6%) were separated, divorced or widowed.
- Less than half (40%) had child(ren) and, of these, 46% reported their chil(ren) had lived with them; sixteen prisoners had lived as married-couples with child(ren).
- A third (36%) had history of having been placed in care and 41% had experienced homelessness; 15% were living in accommodations that could be classified as 'non-stable' (including homelessness) just prior to prison. Females were two times more likely to have been homeless and had been homeless for longer when compared to males.
- At the time of examination, prisoners had on average been incarcerated for 2.55 years and most (94%) had a prior history of imprisonment. As expected, adult males, from the long-stay prison, experienced significantly longer and higher numbers of imprisonments, when compared with females and male young offenders.
- Just over half (52%) self-reported a medical condition known to share common risk factors with dental caries. A quarter (n = 77), were taking medication(s) with dry mouth indicated as a side effect; females were two times more likely to be taking such medicines than males.
- 75% smoked cigarettes and of these at least 50% in all three populations smoked 15 or more cigarettes per day.
- High proportions (79%) self-reported prior (illegal) drug use and 19% indicated problematic substance use requiring participation in a drug rehabilitation programme. Among adults, higher proportions of females (32%) reported intravenous drug use than males (19%).
- Half (50%) had attended the prison dentist and 56% had at least one lifetime attendance for a preventive dental treatment. Under-utilization of dental services was also evident in almost a quarter of prisoners and 2% had never attended a dentist.
- Both toothbrushing and between-meal sugar consumption behaviours were significantly improved in the prison setting among adult males; male young offenders also elicited higher responses for toothbrushing with fluoride toothpaste in the prison setting.
- 67% had last attended the dentist whilst experiencing pain or difficulties. Females were three times more likely to attend for a check-up when compared with males.
- Higher proportions indicated a preference for dental treatment to retain both front (88%) and back teeth (71%) requiring treatment rather than extraction.
- 12% of individuals were dentally phobic and the most feared items were having teeth drilled and local anaesthetic.
- 45% were identified with clinically significant depressive symptoms; females on average had median CES-D scores 8 units higher when compared with adult males.

4.4 Dental caries experience

Eight examined participants (3%) were assessed as caries free ($D_1MFT = 0$) with the remaining 97.3% experiencing some form of caries experience defined as missing, filled or decayed dentition. Seventeen (6%) were assessed with caries experience in all 28 teeth ($D_1MFT = 28$). Caries descriptives are further detailed for each prison population and by gender in Appendix Table 9.3 (page 250). When the data were restricted to include only those with caries extending into dentine ($D_3MFT > 0$) the prevalence remained high with 96% of prisoners affected.

The extent to which the decayed, missing and filled dentition contributed to the two summary scores was uneven, with higher mean scores evident for missing teeth ($\bar{x}$ = 5.90), when compared with filled teeth ($\bar{x}$ = 3.22), and decayed teeth inclusive of white spot lesions ($\bar{x}$ = 2.55), or teeth with decay extending into dentine ($\bar{x}$ = 1.44). As shown in Table 4.8, when examined by prison, this pattern was also apparent for adult males and female prisoners, however, for the male young offender population, on average decayed teeth contributed the most to the summary scores. These differences can be attributed to the fact that the categories of decayed, missing and filled are mutually exclusive and over time (years) decayed dentition will be replaced by filled or missing dentition. This advancement in the disease process, for this study population, is illustrated in Figure 4.7, and section 4.6.1 (Part 2) details the associations between age and the caries outcomes studied.

4.4.1 Missing due to caries

Fifteen people (5%) had no natural teeth (i.e. 28 missing teeth) with the greatest proportion of these (60%) aged 45 years or over. For the remaining 284 dentate participants, more than three quarters (n = 220) had at least one missing tooth resulting from cariogenic activity; values ranged from 1 missing tooth (n = 33) to 27 teeth (n = 1).

A (robust) linear regression, with long-stay adult males as the reference group, found females did not significantly differ from adult males with respect to missing teeth (MT) scores (unadjusted β = -0.70 (95% CI -3.0, 1.6), p = 0.547), however male young offenders had significantly lower MT scores (unadjusted β = -6.19 (95% CI -7.9, -4.5), p < 0.001) when compared with adult males.

4.4.2 Restorations

Two hundred and fourteen participants (72%) had at least one filled tooth and the total number of filled teeth (excluding sealants) ranged from 1 (n = 40) to 16 (n = 1). The mean number of fillings across all examined respondents was 3.21 (SD = 3.33) (Table 4.8).

As with missing dentition, a robust linear regression, with long-stay adult males as the reference group, found females did not significantly differ from adult males with respect to filled teeth (FT) scores (unadjusted β = -0.64 (95% CI -1.6, 0.3), p = 0.195), however male young offenders had significantly lower FT scores (unadjusted β = -2.14 (95% CI -3.0, -1.3), $p < 0.001$) when compared with adult males.

4.4.3 Coronal caries

One hundred and ninety respondents (64%) were assessed as experiencing decay at any manifestation i.e. including white spot lesions (D_1T) and the mean number of teeth affected was 2.55 (SD = 3.08). When restricted to decay extending to the dentine (D_3T) just under half (48%) of the study population were affected and mean number of teeth scored as D_3T was 1.44 (SD = 2.13) (Table 4.8).

The robust linear regressions, with long-stay adult males as the reference group, found females did not have significantly different D_1T (unadjusted β = 0.34 (95% CI -0.4, 1.1), p = 0.321) or D_3T scores (unadjusted β = 0.09 (95% CI -0.4, 0.6), p = 0.726), when compared with adult males. Both D_1T and D_3T scores were significantly different between the male young offender and adult male populations although, for these dental measures, male young offenders had significantly *higher* D_1T (unadjusted β = 2.56 (95% CI 1.7, 3.4), $p < 0.001$) and D_3T scores (unadjusted β = 1.26 (95% CI 0.7, 1.9), $p < 0.001$).

Severe caries extending into dental pulp (D_4T) was calculated for the purpose of allowing for comparisons with previous dental surveys. In this study population, 32% of all prisoners had severe caries into dental pulp and the mean number of teeth affected was 0.74 (SD = 1.45) for the full 32 dentition, and 0.71 (SD = 1.40) when restricted to 28 teeth (excluding third molars).

Table 4.8 Total and sub-component, decayed, missing and filled, caries scores

		Population	Prevalence N (%)	Mean (*SD*)	Median (25th, 75th percentiles)	Range
Missing teeth (MT)		**All prisoners**	**234 (78.5)**	**5.90 (7.42)**	**3 (1, 8)**	**0-28**
		Females	78 (86.7)	7.47 (8.07)	4 (2, 11)	0-28
		Long-stay adult males	97 (89.0)	8.17 (8.22)	5 (3, 11)	0-28
		Male young offenders	59 (59.6)	1.97 (3.06)	1 (0, 3)	0-20
Filled teeth (FT)		**All prisoners**	**214 (71.8)**	**3.21 (3.33)**	**2 (0, 5)**	**0-16**
		Females	65 (72.2)	3.48 (3.57)	2 (0, 6)	0-13
		Long-stay adult males	88 (80.7)	4.12 (3.33)	4 (1, 6)	0-16
		Male young offenders	61 (61.6)	1.98 (2.70)	1 (0, 3)	0-14
Total obvious decay experience	**Decayed (D$_1$T)**	**All prisoners**	**190 (63.8)**	**2.55 (3.08)**	**1 (0, 4)**	**0-14**
		Females	50 (55.6)	1.94 (2.59)	1 (0, 3)	0-13
		Long-stay adult males	58 (53.2)	1.59 (2.45)	1 (0, 2)	0-13
		Male young offenders	82 (82.8)	4.15 (3.49)	4 (1, 6)	0-14
	TOTAL (D$_1$MFT)	**All prisoners**	**290 (97.3)**	**11.66 (7.08)**	**11 (6, 16)**	**0-28**
		Females	90 (100.0)	12.89 (7.55)	12 (7, 17)	1-28
		Long-stay adult males	107 (98.2)	13.87 (7.24)	13 (9, 20)	0-28
		Male young offenders	93 (93.9)	8.10 (4.77)	8 (5, 11)	0-23
Caries into dentine	**Decayed (D$_3$T)**	**All prisoners**	**142 (47.7)**	**1.44 (2.13)**	**0 (0, 2)**	**0-12**
		Females	40 (44.4)	1.08 (1.74)	0 (0, 1)	0-8
		Long-stay adult males	39 (35.8)	0.99 (1.74)	0 (0, 2)	0-9
		Male young offenders	63 (63.6)	2.25 (2.58)	2 (0, 4)	0-12
	TOTAL (D$_3$MFT)	**All prisoners**	**286 (96.0)**	**10.55 (7.39)**	**9 (5, 14)**	**0-28**
		Females	88 (97.8)	12.02 (7.92)	11 (5, 17)	0-28
		Long-stay adult males	107 (98.2)	13.28 (7.32)	12 (8, 18)	0-28
		Male young offenders	91 (91.9)	6.20 (4.46)	5 (3, 8)	0-20

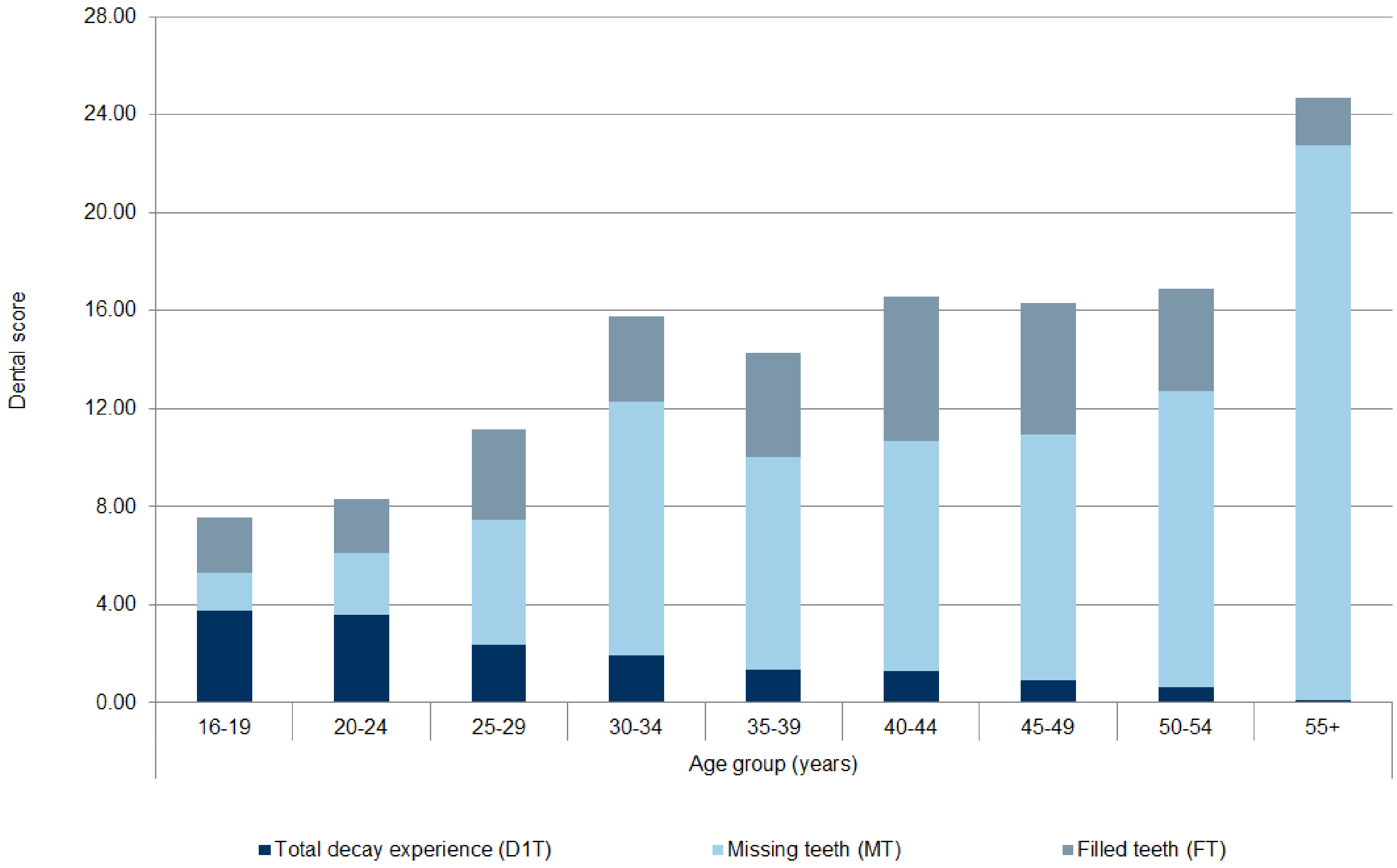

Figure 4.7 Contribution of decayed, missing, and filled dentition to D_1MFT by age grouping

4.4.4 Caries summary scores

The methods for computing the summary scores are detailed in section 3.8.2.2. The total mean scores for total caries (inclusive of caries white spot lesions) (D_1MFT) was 11.66 (SD = 7.08) and the equivalent mean score for caries into dentine (D_3MFT) was 10.55 (SD = 7.39); the dental scores for each population surveyed are reported in Table 4.8.

The distributions for both summary scores were not similar for the three prisons, as assessed by visual inspection of a boxplot (Figure 4.8 for total obvious decay experience & Figure 4.9 for caries into dentine). The median scores for both summary measures were lower for male young offenders where one outlier was also evident for D_1MFT scores (Figure 4.8) and 5 outliers for D_3MFT scores (Figure 4.9). By contrast, no outliers were evident for the adult male or female populations although the range of scores were also much larger. Furthermore, whilst the median values for the adult male and female populations were more similar the data for adult males was also more skewed to the left (lower end of DMFT scale).

For total obvious decay experience, (robust) linear regressions, with long-stay adult males as the reference group, found females did not differ significantly from adult male prisoners (unadjusted β = -1.0 (95% CI -3.1, 1.1), p = 0.352) however male young offenders had significantly lower D_1MFT scores (unadjusted β = -5.8 (95% CI -7.4, -4.1), $p < 0.001$).

Similarly, for caries into dentine scores, females did not differ significantly from adult male prisoners (unadjusted β = -1.3 (95% CI -3.4, 0.9), p = 0.251) however male young offenders had significantly lower D_3MFT scores (unadjusted β = -7.1 (95% CI -8.7, -5.4), $p < 0.001$).

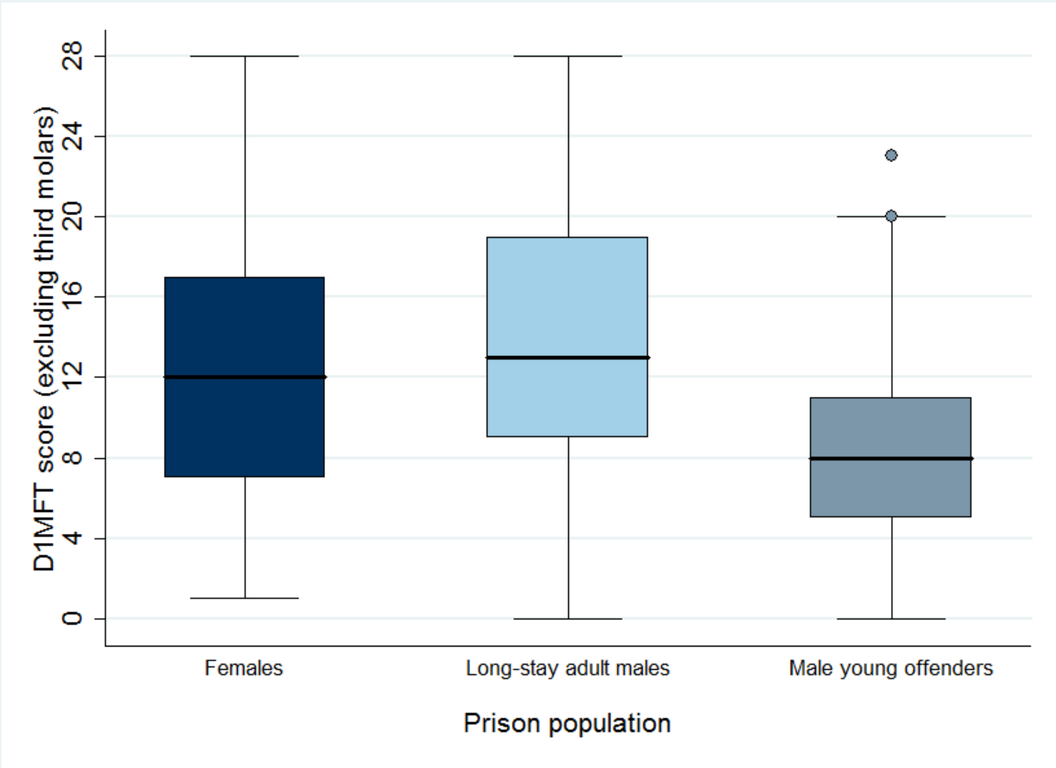

Figure 4.8 Boxplot of total obvious decay experience in Scottish prisoners, 2011

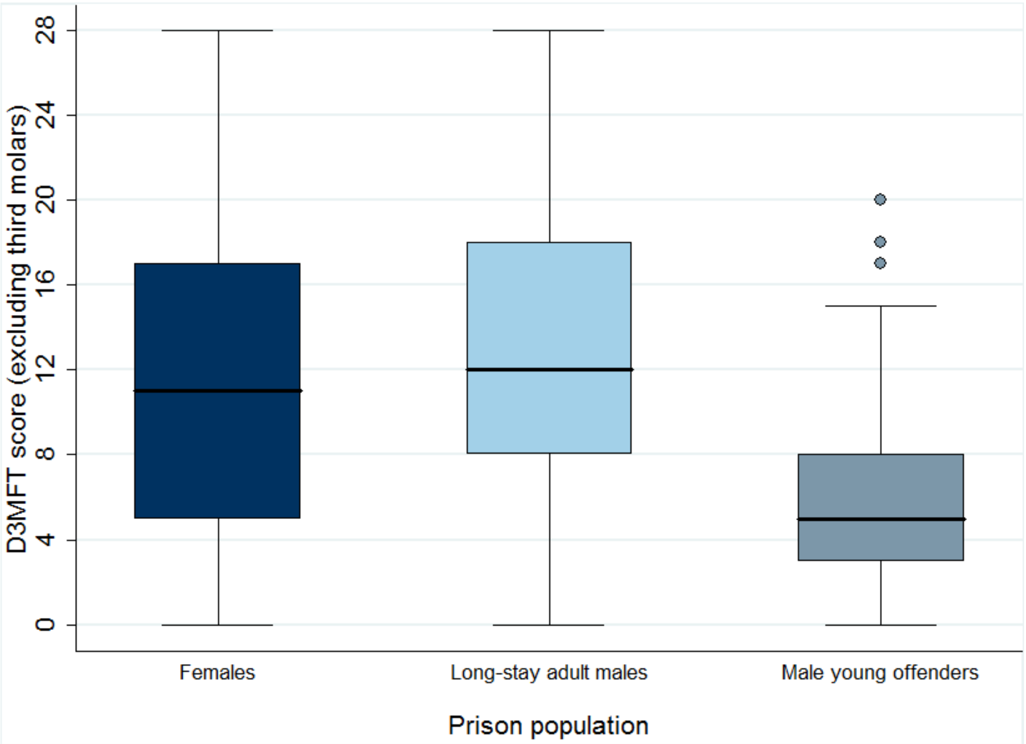

Figure 4.9 Boxplot of caries into dentine in Scottish prisoners, 2011

Summary of dental caries experience

- Eight (3%) participants were caries free with no females examined represented in this category; conversely for *n* = 17 (6%) prisoners, recruited from the adult male and female prisons, all 28 teeth were affected by caries.
- Overall prevalence of obvious decay experience (D_1MFT) was 97% in the study population and varied from 94% for male young offenders to 100% for females.
- Mean D_1MFT scores for all prisoners were 11.66 (*SD* = 7.08), and varied by prison from 8.10 (*SD* = 4.77) for male young offenders to 13.87 (*SD* = 7.24) for adult males.
- Overall prevalence of decay into dentine (D_3MFT) was 96% and varied from 92% for male young offenders to 98% for both long-stay adult males and female prisons.
- Mean D_3MFT scores for all prisoners were 10.55 (*SD* = 7.39), and varied by prison from 6.20 (*SD* = 4.46) for male young offenders to 13.28 (*SD* = 7.32) for adult males.
- Male young offenders had significantly lower scores for both DMFT caries outcomes however these findings were attributable to their younger age.
- Mean number of missing teeth (MT) was 5.90 (*SD* = 7.42) and varied from 1.97 (*SD* = 3.06) for male young offenders to 8.17 (*SD* = 8.22) for adult males. Five percent of prisoners examined were edentate; among the dentate participants, more than three quarters (79%) had at least one missing tooth.
- Mean number of filled teeth (FT) was 3.21 (*SD* = 3.33) and 72% had at least one filled but otherwise sound tooth. Mean FT scores varied from 1.98 (*SD* = 2.70) among male young offenders to 4.12 (*SD* = 3.33) for adult males.
- Sixty-four percent had decayed teeth inclusive of white spot lesions (D_1T) with mean number teeth 2.55 (*SD* = 3.08). Mean D_1T scores varied from 1.59 (*SD* = 2.45) among adult males to 4.15 (*SD* = 3.49) for male young offenders.
- Forty-eight percent had severely decayed teeth with caries extending into dentine (D_3T); mean number of teeth affected was 1.44 (*SD* = 2.13). Mean D_3T scores varied from 0.99 (*SD* = 1.74) among adult males to 2.25 (*SD* = 2.58) for male young offenders.

Part 2: Tests of associations

A number of statistical methods were used to measure the degree of association between variables (see section 3.9.2 for detailed methods). Non-parametric methods were utilized to assess associations between [i] the potential risk indicators, and [ii] the potential risk indicators and each of the dental caries outcomes: total obvious decay experience (D_1MFT scores) and caries into dentine (D_3MFT scores). Relationships between the potential risk indicators and dental caries scores were further assessed by robust linear regression analyses adjusted for age (*and gender* when analyzing all prisons combined). The results for associations between potential risk indicators are reported in section 4.5 and the findings for associations between potential risk indicators and the caries outcomes are in section 4.6. From the descriptive analyses (section 4.3), thirty-two potential risk indicators (outside of age and gender) were considered:

- *Socio-demographics:* educational attainment, unemployment, social occupational position, family (marital status, parenthood/shared residence), living circumstances (non-stable accommodation, homelessness, length of homelessness, placed 'in care'), prison experience (time imprisoned, length current imprisonment, number of prior remands, number of prior sentences);
- *Health:* health condition with shared common risk factors and medicinal-related xerostomia (dry mouth) indicated;
- *Health risk behaviours:* smoked cigarettes, number cigarettes smoked per day, (any) drug use, intravenous drug use, participation in drug rehabilitation programme;
- *Dental health behaviours:* attended prison dentist, attended for preventive dental treatment, time since last dental attendance (inside or outside prison), brushed with fluoride toothpaste – at home and in prison, avoided sugar consumption between meals – at home and in prison;
- *Dental attitudes:* reason for last dental attendance, treatment preferences for front tooth (crown, or extraction), and back tooth (fillings, or extraction);
- *Psychosocial health:* depression (CES-D score); dental anxiety (MDAS score).

4.5 Associations between potential risk indicators

Due to the large number of potential risk indicators under consideration (n = 32, excluding age and gender), and their related nature, there was a high likelihood of severe intra-correlation (i.e. multicollinearity) which, if not addressed, could adversely influence the effect sizes calculated in the multiple robust regression models [155]. To identify strongly related variables, results from the Spearman rank-order correlation coefficient (r_s) were used.

Methods are detailed in section 3.9.2, in brief the r_s was calculated for pairs of continuous and/or binary variables where r_s of 0.80-1.0 were considered 'very strong', 0.60-0.79 were 'strong' and 0.40-0.59 were 'moderate'. The 'very strongly' related variables were considered in the data reduction step to minimize multicollinearity (see section 4.7). Weak correlations with r_s less than 0.40 were not considered.

Additionally, Kruskal Wallis test (H) (also called "one-way ANOVA on ranks") was calculated to assess associations between a categorical and a continuous or ordinal measure and the chi-square (χ^2) test of independence was used to compare a categorical with another categorical or binary variable. For all tests, p-values of < 0.05 were used to confirm associations. These tests were important to identify other potential sources of multicollinearity which were formally tested later in the multiple regression models (specifically using the VIF statistic).

Findings of significance are reported here and the test results for r_s can be found in Appendix Table 9.7; for H in Appendix Table 9.8, and for χ^2 in Appendix Table 9.12.

4.5.1 Associations between potential risk indicators: all prisoners

A number of statistically significant (all $p < 0.001$) associations were identified from the Spearman rank order correlations for all prisoners combined (see Appendix Table 9.7 for correlation matrix). Being employed or in education was strongly related to the standard occupational classification (SOC) measure ($r_s = 0.952$), this finding is not unexpected since SOC was an arbitrary measure created from job titles reported by respondents who, by definition, would have been employed. Other examples of similarly related measures included: having ever been homeless and length of homelessness experienced ($r_s = 0.958$); smoking cigarettes and number cigarettes smoked per day ($r_s = 0.758$); and, those imprisoned for longer, were more likely to be in prison for 4 or more years ($r_s = 0.770$). Both homeless measures were also significantly related to having ever tried intravenous drugs ($r_s = 0.399$ ever homeless; $r_s = 0.412$ length of homelessness). Intravenous drug use (IDU) was also significantly associated with an indication of medicinal-related dry mouth ($r_s = 0.441$) and participation in a rehabilitation programme ($r_s = 0.488$). Smoking cigarettes was significantly associated with having tried any (illegal) drugs ($r_s = 0.405$). Age also had a significant and positive relationship with two measures of prison experience [i] longer time spent in prison ($r_s = 0.558$), and a stay of more than 4 years ($r_s = 0.568$). Both longer time imprisoned ($r_s = 0.584$), and a stay of more than 4 years ($r_s = 0.420$), were also significantly associated with every having attended a prison dentist. Separately, number of times remanded had a significant and positive relationship with number of sentenced stays in prison ($r_s = 0.704$). Within the dental attitude measures, preference for restorative treatment rather than extraction for back teeth was significantly associated with the same preference for front teeth requiring treatment ($r_s = 0.482$).

The Kruskal Wallis H and χ^2 tests revealed additional relationships between marital status, parenthood and shared residence, and reason for last dental attendance, and the other potential risk indicators:

There was a statistically significant difference between marital status and [i] age of participants ($H(2) = 34.99$, $p < 0.001$) with mean rank of 128 for those single, 195 for those married or with a partner, and 216 for those separated, widowed or divorced; [ii] CES-D (depression) scores ($H(2) = 7.08$, $p = 0.029$) with mean rank of 111 for those single, 99 for those married or with a partner, and 154 for those separated, widowed or divorced. The Pearson's χ^2/Fisher's exact test results showed significant differences in proportions between marital status groups and [i] attained education ($p = 0.012$), [ii] parenthood and share residence ($p < 0.001$), [iii] length stay in prison ($p = 0.003$), [iv] medicinal-related dry mouth potentially indicated ($p = 0.010$), and [v] any drug use ($p = 0.001$).

For the parenthood and children's residence measure, significant differences were determined by [i] age ($H(2) = 67.04$, $p < 0.001$) with mean rank of 87 for those with no child, 153 for non-resident parents, and 170 for those living in the same residence as their child(ren); and [ii] time imprisoned ($H(2) = 14.84$, $p = 0.001$) with mean ranks of

99, 121, and 140 for no child, living separately from child, and living in same residence as child respectively. The Pearson's χ^2/Fisher's exact test results showed significant differences in proportions of parents, resident parents and non-resident parents by [i] marital status ($p < 0.001$), [ii] stable community accommodation ($p = 0.021$), [iii] length stay in prison ($p < 0.001$), [iv] medical-related dry mouth potentially indicated ($p = 0.027$), and [v] toothbrushing in the home setting ($p = 0.031$).

Reasons given for most recent dental attendance significantly differed by time imprisoned ($H(2) = 14.79$, $p = 0.001$) with mean ranks of 119, 103, and 60 for attendance with trouble, checkup and 'other' reasons respectively; and age ($H(2) = 7.26$, $p = 0.026$), with a mean rank of 126 for those attending because of trouble with teeth or gums, 117 for those attending for a checkup, and 82 for those attending for other reasons. Pearson's χ^2/Fisher's exact test determined significant differences in proportions, among these groups, by gender ($p = 0.011$), length of prison stay ($p = 0.041$), any drug use ($p = 0.034$), attendance at the prison dentist ($p = 0.003$), and preferences for dental treatment for back teeth ($p = 0.016$).

The above relationships were by in large also evident when the tests were repeated for each prison population. Some notable differences were determined and are summarized below. For the Kruskal Wallis, Pearson's χ^2 and Fisher's exact tests the summary below addresses significant differences and it is of note that many of the significant differences noted for *all* prisoners were not sustained (see accompanying Appendix Table 9.8 and Appendix Table 9.12.

4.5.2 Associations between potential risk indicators: females, adult males, and male young offenders

For female prisoners, age was still significantly related to longer time spent in prison however the strength of this relationship was weaker ($r_s = 0.299$, $p = 0.009$). Additionally, having been homeless and being homeless for longer periods of time was significantly related with less time imprisoned ($r_s = -0.418$ homelessness; $r_s = -0.459$ length of homelessness, all $p < 0.001$) as well as a stay in prison of less than 4 years ($r_s = -0.460$ and $r_s = -0.432$ respectively, all $p < 0.001$). In other words, among female prisoners, there was an inverse relationship between length of imprisonment and length of homelessness; and those imprisoned for longer tended to have experienced shorter periods of homelessness. An inverse relationship was also found between long-term imprisonment and history of multiple stays in prison where a prison stay of *more* than 4 years was significantly associated with fewer numbers of remanded stays in prison (r_s = -0.428, $p < 0.001$). However, *more* remanded stays in prison was significantly related to any (illegal) drug use ($r_s = 0.437$, $p < 0.001$), as well as both IDU ($r_s = 0.422$, all p = 0.001), and having participated in drug rehabilitation ($r_s = 0.571$, $p < 0.001$). Moreover, any drug use was also significantly related to IDU ($r_s = 0.509$, $p < 0.001$) and drug rehabilitation ($r_s = 0.462$, $p < 0.001$).

In other findings which differed for the female population, having a health condition with shared common risk factors for caries was associated with taking a medicine with dry mouth potentially indicated as a side effect ($r_s = 0.400$, $p < 0.001$) and, separately, the dental behaviour for avoiding sugars between meals was also significantly related when comparing the home and prison settings ($r_s = 0.490$, $p < 0.001$) and length of homelessness significantly differed by reason for last dental attendance ($H(2) = 7.81$, $p = 0.020$) with mean rank of 35 for when experiencing difficulties, 32 for attendance for check-up, and 64 for 'other' reasons.

For adult long-stay males, notably age only significantly differed by marital status ($H(2) = 18.55$, $p < 0.001$) and was unrelated to any of the other potential indicators ($r_s > 0.40$. Whilst still significant, homelessness and 'non-stable' living accommodation just prior to prison were weakly associated ($r_s = 0.288$, $p = 0.003$). Weak associations were also evident between smoking and any drug use ($r_s = 0.313$, $p = 0.001$), between IDU and an indication of medicinal-related dry mouth ($r_s = 0.374$, $p < 0.001$), and between length of time imprisoned and attendance at the prison dentist ($r_s = 0.386$, $p < 0.001$). Time imprisoned was not significantly associated with a longer term in prison ($r_s = 0.020$, $p = 0.843$); and a prison term longer than 4 years was not significantly associated with attendance at the prison dentist ($r_s = -0.126$, $p = 0.205$). When interpreting the findings pertaining to time spent in prison, it should be noted few ($n < 5$) prisoners from this population were imprisoned for less than 4 years.

For other findings which differed for the adult male population, being placed in care was significantly associated with more remanded stays in prison ($r_s = 0.457$, $p < 0.001$) as well as more cigarettes smoked per day ($r_s = 0.406$, $p < 0.001$). Attendance at the prison dentist was significantly associated with less time since last dental attendance

($r_s = -0.535$, $p < 0.001$). The two dental behaviours for toothbrushing and sugar consumption in the home settting were significantly related with each other ($r_s = 0.408$, $p < 0.001$). Length of homelessness significantly differed by reason for last dental attendance ($H(2) = 6.73$, $p = 0.035$) with mean rank of 46 for when experiencing difficulties, 49 for check-up, and 88 for 'other' reasons; this latter finding should be interpreted with caution since only three adult males attended for 'other' reasons.

For male young offenders, the following differences were noted: age was only significantly associated with more sentenced stays in prison ($r_s = 0.420$, $p < 0.001$) and IDU was not associated with homelessness ($r_s = 0.143$, $p = 0.180$), length of homelessness ($r_s = 0.186$, $p = 0.079$), indication of medicinal-related dry mouth ($r_s = 0.200$, $p = 0.055$), or participation in drug rehabilitation ($r_s = -0.048$, $p = 0.648$). When interpreting the findings for IDU it should be noted few (less than five) male young offenders reported IDU.

4.6 Relationship between potential risk indicators and caries outcomes

This section reports the relationship between the two caries outcome scores (total obvious decay expereience (D_1MFT), and caries into dentine (D_3MFT)) and all potential risk indicators. Associations were initially determined from non-parametric bivariate tests of association and then subsequently assessed by robust linear regression analyses. The methods for each are summarized below and further detailed in section 3.9.

The non-parametric tests were less sensitive than robust linear regression (i.e. less likely to detect association between dental score and potential risk indicator) and could not be adjusted for age (and gender). In some instances a significant association was found in the non-parametric tests ($p < 0.05$) but was not sustained in the corresponding adjusted robust regression; these results could be attributed to confounding by age (and gender) and are summarized in Appendix 9.9.2. All non-parametric test results, for both dental scores, are also reported in the accompanying appendix (see Appendix Table 9.12 and Appendix Table 9.13, for D_1MFT and D_3MFT respectively). The remainder of this section refers to the adjusted robust linear regression models.

The robust linear regressions were adjusted for age (*and gender* when analyzing all prisons combined) and *p*-values of less than 0.1 were considered sufficiently significant to warrant further analyses in the multiple regression models (see Part 3 of results). Table 4.9 summarizes the variance in D_1MFT and D_3MFT scores explained by age and gender. Table 4.10 reports the regression models for D_1MFT scores (adjusted for age and gender) where *p*-values of < 0.05 are indicated by double asterisk (**), and *p*-values > 0.05 and < 0.10 are denoted by a single asterisk (*). Table 4.11 reports the corresponding findings for robust regressions of D_3MFT scores against potential risk indicators (again adjusted for age and gender).

For the whole study population, sixteen potential risk indicators were found for D_1MFT scores (at $p < 0.1$): having met school leaving age, marital status, non-stable accommodation, both homelessness and length of homelessness, history of being placed in care, health condition(s) with shared common risk facotrs, all five health risk measures (smoking, number of cigarettes per day, (any) drug use, intravenous drug use, drug rehabilitation), attendance at the prison dentist, reason for last dental attendance, preference for extraction (rather than restorative treatment) for front tooth, and dental anxiety. For D_3MFT scores, seventeen potential risk indicators were demonstrated (at $p < 0.1$) with all sixteen potential risk indicators for D_1MFT scores again found for D_3MFT scores in addition to time imprisoned.

Supplementary tabulations for various potential risk indicators and the corresponding descriptive data for both D_1MFT and D_3MFT, in the whole study population, can be found in Appendix 9.7.4.

However, when the robust regression analyses were repeated separately for each prison population, the above significant findings were not always sustained, and in some instances different risk indicators were found. Thus it was apparent the findings varied by population of study and it would be more meaningful to consider potential risk indicators by the prison population of study i.e. females, long-stay adult males, and male young offenders. The remainder of section 5 details the findings accordingly.

4.6.1 Association between age, gender and caries

Spearman rank-order correlations revealed age was significantly ($p < 0.0001$) related to both caries outcomes with a moderately strong and positive association with D_1MFT scores ($r_s = 0.5465$) and a stronger positive association with D_3MFT scores ($r_s = 0.6305$). Figure 4.10 shows the distribution of both scores by gender and discrete age groupings; the age groupings are for illustration purposes only and age was analysed as a continuous measure throughout.

Males and females had similar D_1MFT median scores (10 for males vs 12 for females) and the Wilcoxon rank sum (Z) test showed there was no significant difference between males and females for the ranks of these scores ($Z = 1.836$, $p = 0.066$) where the mean ranks were 143.5 for males and 163.4 for females. For caries into dentine, males had a median D_3MFT score of 8 compared to 11 for females and the ranks of D_3MFT scores did not significantly differ between males and females ($Z = 2.169$, $p = 0.030$), where mean ranks were 142.3 and 165.9 respectively.

There were too few females (i.e. 16) under the age of 21 years in the study population to be able to reliably compare males and females below 21 years of age. To understand how much of the variance in D_1MFT and D_3MFT scores was explained by age and gender, robust regressions were therefore performed for the whole study population and separately for those aged ≥ 21 years of age (see Table 4.9). There was little evidence that gender on its own explained any of the variation in D_1MFT scores. Gender was however associated with severe caries into dentine scores in the total study population with only 1% of variance in D_3MFT scores explained and the relationship between gender and D_3MFT scores disappeared in the analyses of older prisoners. Together, age and gender accounted for 32% of the variance in D_1MFT scores ($F(2, 295) = 69.3$, $p < 0.0001$) and 39% in caries into dentine scores ($F(2, 295) = 93.4$, $p < 0.0001$).

Table 4.9 Association between age, gender and D_1MFT and D_3MFT scores for whole study population and prisoners over 21 years of age

Outcome	Predictor variable(s)	Adjusted R^2	*F*	*df*1	*df*1	*P*-value
Whole population						
D_1MFT	Age	0.315	138.28	1	296	**<0.0001**
D_1MFT	Gender	0.010	3.64	1	296	0.0572
D_1MFT	Age + gender	0.316	69.34	2	295	**<0.0001**
D_3MFT	Age	0.387	186.55	1	296	**<0.0001**
D_3MFT	Gender	0.014	4.78	1	296	**0.0296**
D_3MFT	Age + gender	0.389	93.44	2	295	**<0.0001**
Adults prisoners ≥ 21 years of age						
D_1MFT	Age	0.221	58.13	1	187	**<0.0001**
D_1MFT	Gender	-0.003	0.36	1	187	0.5494
D_1MFT	Age + gender	0.225	31.31	2	186	**<0.0001**
D_3MFT	Age	0.251	69.65	1	187	**<0.0001**
D_3MFT	Gender	-0.003	0.49	1	187	0.4850
D_3MFT	Age + gender	0.256	37.52	2	186	**<0.0001**

Table 4.10 Age, gender adjusted beta-coefficients for individual potential risk indicators from robust regressions of D_1MFT scores, stratified by prison

Potential risk indicator	All prisoners		Females		Long-stay adult males		Male young offenders	
	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value
Age (years) (adjusted for gender)	0.35 (0.29, 0.41)	<0.001**	0.39 (0.27, 0.52)	<0.001**	0.39 (0.29, 0.49)	<0.001**	0.38 (-0.64, 1.40)	0.462
Female (adjusted for age)	0.87 (-0.59, 2.33)	0.242	-	-	-	-	-	-
Standard Occupational Classification		0.650		0.360		0.919		0.065
Routine and manual	1.0		1.0		1.0		1.0	
Managerial and professional	3.06 (-4.03, 10.14)	0.392	9.29 (-4.41, 22.98)	0.168	-0.01 (-3.45, 3.44)	0.998	-1.80 (-4.66, 1.07)	0.203
Intermediate	0.82 (-2.14, 3.77)	0.583	2.91 (-5.11, 10.94)	0.450	-0.72 (-5.61, 4.18)	0.765	1.67 (-2.96, 6.30)	0.457
Unemployed	1.23 (-0.21, 2.73)	0.108	1.67 (-1.99, 5.32)	0.367	1.88 (-0.53, 4.29)	0.124	0.16 (-2.17, 2.48)	0.895
Met school leaving age (16 years)	-1.51 (-2.83, -0.19)	0.025**	-3.01 (-6.01, -0.01)	0.049**	-1.56 (-3.87, 0.76)	0.185	-0.20 (-2.10, 1.70)	0.837
Marital status		0.089*		0.144		0.346		0.205
Single	1.0		1.0		1.0		1.0	
Married/cohabiting	-2.34 (-4.45, -0.24)	0.029**	-4.01 (-8.06, 0.03)	0.052*	-2.20 (-5.49, 1.08)	0.186	-1.09 (-3.90, 1.72)	0.442
Separated/divorced/widowed	-1.00 (-4.75, 2.75)	0.600	-0.37 (-6.45, 7.72)	0.904	-2.07 (-7.53, 3.39)	0.453	1.24 (-0.56, 3.04)	0.173
Shared residence with child(ren)		0.505		0.124		0.055*		0.491
Non-resident parent	1.0		1.0		1.0		1.0	
Resident parent	-1.08 (-3.24, 1.07)	0.323	-3.80 (-8.18, 0.59)	0.089*	-1.07 (-3.96, 1.82)	0.463	3.21 (-2.23, 8.65)	0.244
Had no children	-0.01 (-1.97, 1.99)	0.991	-4.67 (-9.25, -0.09)	0.046**	3.26 (-0.30, 6.82)	0.072*	0.58 (2.55, -3.70)	0.713
Non-stable accommodation just prior to prison	2.38 (0.44, 4.31)	0.016**	0.81 (-2.65, 4.27)	0.643	6.33 (3.00, 9.65)	<0.001**	-0.38 (-3.39, 2.63)	0.804
Ever homeless	2.57 (1.13, 4.01)	<0.001**	3.58 (0.80, 6.36)	0.012**	4.57 (1.96, 7.17)	0.001**	-0.48 (-2.75, 1.80)	0.680
Length homelessness	1.16 (0.55, 1.76)	<0.001**	1.30 (0.33, 2.26)	0.009**	2.24 (1.13, 3.34)	<0.001**	-0.38 (-1.27, 0.52)	0.403
Placed ‘in care’	1.71 (0.25, 3.17)	0.022**	1.23 (-2.01, 4.46)	0.453	3.75 (1.22, 6.28)	0.004**	0.27 (-1.74, 2.27)	0.793
Time imprisoned (years)	0.14 (-0.04, 0.31)	0.136	0.18 (-0.08, 0.44)	0.175	0.09 (-0.11, 0.29)	0.361	0.15 (-0.32, 0.61)	0.533
Length current stay in prison >4 years	0.00 (-1.68, 1.68)	0.998	-1.57 (-5.22, 2.08)	0.394	-0.76 (-3.73, 2.22)	0.615	2.50 (0.23, 5.25)	0.073
Number of remands	0.11 (-0.07, 0.30)	0.239	0.69 (0.11, 1.26)	0.021**	0.05 (-0.17, 0.27)	0.665	0.09 (-0.16, 0.35)	0.464
Number of sentences	0.10 (-0.03, 0.24)	0.138	0.66 (0.24, 1.08)	0.002**	0.07 (-0.08, 0.22)	0.336	-0.56 (-1.06, -0.06)	0.028**

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Potential risk indicator	All prisoners		Females		Long-stay adult males		Male young offenders	
	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value
Health condition with common risk factors	1.96 (0.52, 3.40)	0.008**	2.54 (-0.24, 5.32)	0.072*	3.15 (0.35, 5.96)	0.028**	0.29 (-1.94, 2.52)	0.796
Medicinal-related dry mouth potentially indicated	1.08 (-0.78, 2.94)	0.254	3.26 (0.34, 6.18)	0.029**	0.13 (-2.69, 2.95)	0.928	-2.94 (-6.21, 0.33)	0.078*
Smoking cigarettes	2.75 (1.27, 4.23)	<0.001**	5.11 (2.49, 7.73)	<0.001**	3.36 (1.05, 5.68)	0.005**	-0.47 (-3.26, 2.31)	0.738
Number of cigarettes smoked per day	0.12 (0.06, 0.18)	<0.001**	0.19 (0.08, 0.31)	0.001**	0.14 (0.03, 0.25)	0.014**	0.04 (-0.06, 0.14)	0.395
Any (illegal) drug use	3.41 (1.71, 5.12)	<0.001**	4.23 (1.78, 6.67)	0.001**	3.56 (0.57, 6.56)	0.020**	0.96 (-2.74, 4.65)	0.608
Intravenous drug use	4.83 (2.66, 7.00)	<0.001**	7.06 (3.99, 10.12)	<0.001**	4.89 (1.72, 8.06)	0.003**	-6.74 (-10.02, -3.47)	<0.001**
Participated drug rehabilitation programme	3.20 (1.28, 5.12)	0.001**	4.87 (1.58, 8.16)	0.004**	2.90 (-0.13, 5.93)	0.061*	-0.32 (-2.93, 2.28)	0.806
Attended prison dentist	1.95 (0.47, 3.37)	0.010**	2.43 (-0.67, 5.53)	0.123	2.22 (-0.37, 4.80)	0.092*	1.79 (-0.32, 3.89)	0.095*
Attended for preventive dental treatment	-0.66 (-2.45, 1.13)	0.469	2.26 (-1.78, 6.30)	0.269	-2.87 (-6.03, 0.30)	0.075*	-0.21 (-2.63, 2.20)	0.861
Time since last dental attendance	-0.37 (-0.85, 0.12)	0.138	-0.66 (-1.62, 0.30)	0.174	-0.05 (-1.04, 0.95)	0.925	-0.44 (-1.09, 0.22)	0.187
Avoid sugar between meals at home	-0.54 (-1.98, 0.91)	0.467	1.92 (-0.89, 4.73)	0.178	-2.40 (-4.91, 0.11)	0.061*	-1.61 (-3.65, 0.42)	0.118
Avoid sugar between meals in prison	-0.17 (-1.56, 1.21)	0.805	0.19 (-2.64, 3.01)	0.897	-1.76 (-4.05, 0.54)	0.132	1.31 (-0.89, 3.51)	0.241
Brushed teeth at home	-0.96 (-2.64, 0.73)	0.264	1.59 (-3.14, 6.31)	0.506	-1.98 (-4.37, 0.41)	0.103	-0.85 (-3.42, 1.71)	0.511
Brushed teeth in prison	0.01 (-2.50, 2.52)	0.996	0.21 (-4.02, 4.45)	0.921	-0.57 (-6.65, 5.51)	0.853	0.46 (-2.27, 3.18)	0.739
Reason last dental attendance		0.023**		0.007**		0.835		0.441
Problem with teeth/gums	1.0		1.0		1.0		1.0	
For check-up	-2.19 (-3.75, -0.62)	0.006**	-4.07 (-6.75, -1.40)	0.003**	-0.80 (-3.92, 2.32)	0.612	-1.26 (-3.60, 1.08)	0.287
Other reason	-1.08 (-3.57, 1.42)	0.397	1.16 (-5.22, 7.54)	0.718	-1.68 (-10.98, 7.62)	0.721	-1.37 (-3.96, 1.22)	0.296
Preferred extraction for back tooth requiring filled	1.05 (-0.52, 2.62)	0.189	4.22 (1.28, 7.17)	0.006**	-0.07 (-2.81, 2.68)	0.962	-1.06 (-3.28, 1.16)	0.345
Preferred extraction front tooth needs crowned	2.43 (-0.24, 5.10)	0.074*	6.45 (1.61, 11.28)	0.010**	-0.73 (-5.79, 4.32)	0.774	1.90 (-1.53, 5.33)	0.274
Dental anxiety (MDAS score)	0.15 (0.02, 0.27)	0.023**	0.11 (-0.12, 0.34)	0.356	0.14 (-0.09, 0.38)	0.220	0.21 (0.02, 0.40)	0.027**
Depression (CES-D score)	0.03 (-0.03, 0.09)	0.317	0.06 (-0.08, 0.20)	0.379	0.07 (-0.06, 0.20)	0.294	-0.02 (-0.08, 0.05)	0.662

* Unstandardized β *p*-value is significant at 0.1 level; ** Unstandardized β *p*-value is significant at 0.05 level

Table 4.11 Age, gender adjusted beta-coefficients for individual potential risk indicators from robust regressions of D_3MFT scores, stratified by prison

Potential risk indicator	All prisoners		Females		Long-stay adult males		Male young offenders	
	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value
Age (years) (adjusted for gender)	0.41 (0.35, 0.47)	<0.001**	0.39 (0.27, 0.52)	<0.001**	0.39 (0.29, 0.49)	<0.001**	0.38 (-0.64, 1.39)	0.462
Female (adjusted for age)	1.08 (-0.36, 2.52)	0.140	-	-	-	-	-	-
SOC		0.767		0.403		0.910		0.063*
Routine and manual	1.0		1.0		1.0		1.0	
Managerial and professional	2.79 (-4.85, 10.43)	0.468	9.10 (-5.57, 23.77)	0.205	-0.67 (-4.21, 2.87)	0.701	-3.67 (-6.43, -0.92)	0.012**
Intermediate	0.26 (-2.68, 3.20)	0.858	2.80 (-4.43, 10.03)	0.420	-1.01 (-6.11, 4.10)	0.688	0.17 (-4.34, 4.68)	0.938
Unemployed	1.00 (-0.48, 2.48)	0.185	1.88 (-1.66, 5.43)	0.294	1.83 (-0.60, 4.26)	0.138	-0.51 (-2.78, 1.77)	0.660
Met school leaving age (16 years)	-1.48 (-2.79, -0.18)	0.026**	-2.95 (-6.06, 0.17)	0.064*	-1.21 (-3.51, 1.09)	0.300	-0.62 (-2.39, 1.16)	0.491
Marital status		0.049**		0.172		0.366		0.001**
Single	1.0		1.0		1.0		1.0	
Married/cohabiting	-2.54 (-4.65, -0.44)	0.018**	-3.84 (-7.98, 0.29)	0.068*	-2.26 (-5.61, 1.10)	0.186	-1.99 (-4.07, 0.09)	0.060*
Separated/divorced/widowed	-0.64 (-4.35, 3.07)	0.735	0.18 (-5.91, 6.27)	0.953	-1.73 (-7.08, 3.62)	0.522	2.38 (0.67, 4.09)	0.007**
Shared residence with child(ren)		0.605		0.090*		0.042**		0.492
Non-resident parent	1.0		1.0		1.0		1.0	
Resident parent	-1.09 (-3.24,1.07)	0.322	-3.26 (-7.61, 1.10)	0.140	-1.17 (-4.06,1.72)	0.422	2.46 (-3.53,8.46)	0.416
Had no children	-0.65 (-2.61,1.31)	0.513	-4.99 (-9.46,-0.53)	0.029**	3.25 (-0.24,6.74)	0.068*	-0.63 (-3.72,2.46)	0.688
Non-stable accommodation just prior to prison	2.43 (0.50, 4.37)	0.014**	0.42 (-3.17, 4.02)	0.815	6.19 (2.93, 9.44)	<0.001**	0.59 (-2.28, 3.45)	0.686
Ever homeless	2.65 (1.25, 4.05)	<0.001**	2.79 (-0.04, 5.62)	0.053*	4.69 (2.13, 7.24)	<0.001**	0.44 (-1.67, 2.54)	0.682
Length homelessness	1.15 (0.55, 1.76)	<0.001**	1.11 (0.10, 2.11)	0.031**	2.24 (1.16, 3.33)	<0.001**	-0.02 (-0.90, 0.85)	0.956
Placed 'in care'	1.61 (0.16, 3.06)	0.030**	1.31 (-1.94, 4.55)	0.425	4.06 (1.54, 6.58)	0.002**	-0.28 (-2.16, 1.60)	0.768
Time imprisoned (years)	0.16 (-0.02, 0.34)	0.078*	0.20 (-0.06, 0.46)	0.132	0.11 (-0.09, 0.32)	0.273	0.14 (-0.21, 0.49)	0.439
Length current stay in prison >4 years	-0.22 (-1.82, 1.38)	0.783	-1.65 (-5.28, 1.99)	0.370	-1.44 (-4.11, 1.22)	0.285	0.32 (-2.14, 2.78)	0.796
Number of remands	0.10 (-0.08, 0.28)	0.256	0.71 (0.08, 1.34)	0.028**	0.06 (-0.16, 0.27)	0.613	0.01 (-0.20, 0.22)	0.927
Number of sentences	0.11 (-0.03, 0.25)	0.105	0.72 (0.29, 1.15)	0.001**	0.08 (-0.07, 0.22)	0.281	-0.60 (-1.12, -0.09)	0.023**

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Potential risk indicator	All prisoners		Females		Long-stay adult males		Male young offenders	
	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value	Coefficient (95% CI)	*P*-value
Health condition with common risk factors	2.37 (0.96, 3.79)	0.001**	2.29 (-0.52, 5.09)	0.109	3.94 (1.21, 6.68)	0.005**	1.17 (-0.97, 3.31)	0.281
Medicinal-related dry mouth potentially indicated	1.22 (-0.62, 3.05)	0.192	3.46 (0.48, 6.44)	0.023**	-0.16 (-2.91, 2.59)	0.910	-2.01 (-4.81, 0.79)	0.157
Smoking cigarettes	2.56 (1.10, 4.01)	0.001**	5.18 (2.56, 7.80)	<0.001**	3.32 (0.97, 5.68)	0.006**	-0.98 (-3.34, 1.38)	0.411
Number of cigarettes smoked per day	0.10 (0.03, 0.16)	0.003**	0.18 (0.06, 0.31)	0.005**	0.14 (0.03, 0.25)	0.016**	-0.02 (-0.10, 0.06)	0.580
Any (illegal) drug use	3.64 (2.01, 5.26)	<0.001**	4.61 (2.25, 6.97)	<0.001**	3.97 (1.09, 6.85)	0.007**	0.30 (-2.60, 3.20)	0.837
Intravenous drug use	5.17 (2.99, 7.36)	<0.001**	7.37 (4.25, 10.49)	<0.001**	4.96 (1.71, 8.21)	0.003**	-4.80 (-1.52, -8.08)	0.005**
Participated drug rehabilitation programme	3.52 (1.58, 5.47)	<0.001**	5.20 (1.83, 8.57)	0.003**	3.08 (0.02, 6.15)	0.049**	0.22 (-2.06, 2.49)	0.851
Attended prison dentist	2.06 (0.63, 3.50)	0.005**	2.67 (-0.46, 5.80)	0.093*	2.89 (0.44, 5.33)	0.021**	0.77 (-1.17, 2.70)	0.433
Attended for preventive dental treatment	-0.67 (-2.43, 1.09)	0.455	2.47 (-1.51, 6.46)	0.220	-3.21 (-6.30, -0.13)	0.041**	-0.29 (-2.67, 2.08)	0.805
Time since last dental attendance	-0.37 (-0.84, 0.11)	0.126	-0.76 (-1.69, 0.17)	0.108	-0.12 (-1.11, 0.87)	0.808	-0.22 (-0.82, 0.39)	0.481
Avoid sugar between meals at home	-0.41 (-1.85, 1.03)	0.577	1.71 (-1.13,4.56)	0.235	-2.56 (-5.04, -0.08)	0.043**	-0.85 (-2.80, 1.11)	0.391
Avoid sugar between meals in prison	-0.36 (-1.72, 1.00)	0.602	-0.25 (-3.09, 2.58)	0.859	-1.68 (-3.96, 0.59)	0.145	1.08 (-0.99, 3.15)	0.305
Brushed teeth at home	-0.85 (-2.53, 0.84)	0.323	1.02 (-3.87, 5.91)	0.679	-2.25 (-4.63, 0.14)	0.065*	0.20 (-2.23, 2.64)	0.869
Brushed teeth in prison	0.11 (-2.40, 2.61)	0.935	0.22 (-4.10, 4.53)	0.922	-0.87 (-7.08, 5.34)	0.782	0.76 (-1.66, 3.18)	0.534
Reason last dental attendance		0.018**		0.014**		0.816		0.447
Problem with teeth/gums	1.0		1.0		1.0		1.0	
For check-up	-2.20 (-3.70, -0.69)	0.004**	-3.77 (-6.49, -1.04)	0.007**	-0.95 (-4.01, 2.12)	0.541	-1.19 (-3.13, 0.75)	0.225
Other reason	-0.87 (-3.20, 1.47)	0.466	1.44 (-4.87, 7.74)	0.650	-1.04 (-10.26, 8.19)	0.824	-1.01 (-3.26, 1.24)	0.374
Preferred extraction for back tooth requiring filled	1.11 (-0.47, 2.68)	0.167	4.13 (1.07, 7.19)	0.009**	0.01 (-2.70, 2.72)	0.996	-0.81 (-2.96, 1.33)	0.454
Preferred extraction front tooth needs crowned	2.38 (-0.37, 5.13)	0.090*	6.46 (1.16, 11.76)	0.018**	-0.36 (-5.46, 4.74)	0.889	1.53 (-1.89, 4.96)	0.376
Dental anxiety (MDAS score)	0.13 (0.01, 0.26)	0.041**	0.08 (-0.15, 0.31)	0.491	0.12 (-0.10, 0.35)	0.284	0.21 (0.02, 0.41)	0.033**
Depression (CES-D score)	0.04 (-0.02, 0.10)	0.240	0.06 (-0.09, 0.20)	0.433	0.08 (-0.06, 0.22)	0.243	-0.00 (-0.07, 0.06)	0.956

* Unstandardized β *p*-value is significant at 0.1 level; ** Unstandardized β *p*-value is significant at 0.05 level

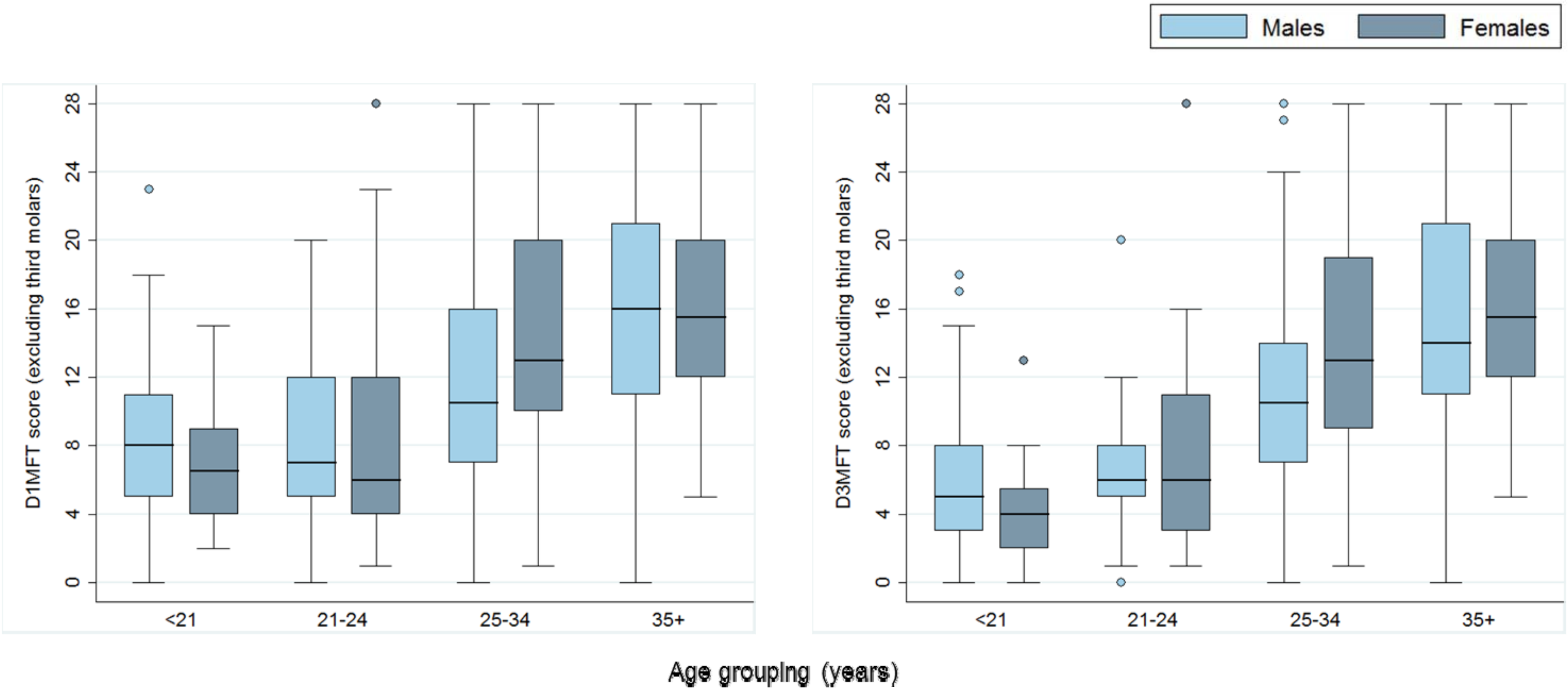

Figure 4.10 Total decay experience and caries into dentine by gender and age grouping

4.6.2 Association between socio-demographics and caries

Being unemployed, when compared to those either employed or in education, did not predict either total caries (D_1MFT) or caries into dentine (D_3MFT) scores in any of the three prison populations. Similarly, standard occupational classification (SOC) was not associated with either dental scores with the exception of male young offenders, where those in Management level occupations had significantly lower D_1MFT scores (β = -3.67 (95% CI -6.43, -0.92)) when compared to Routine and Manual jobs ($p = 0.012$); however this latter result pertained to very few observations (less than 5) in the Management group thus was deemed unreliable for further consideration in the "multivariable" analyses (see Table 4.10 and Table 4.11 for exact *p*-values).

The remaining socio-demographic concepts of education, family and living circumstances, and prison experiences were related to the outcomes of interest and each of these concepts are explored in detail below. The average D_1MFT and D_3MFT experience for all socio-demographic measures are reported in Table 4.12 on page 132.

4.6.2.1 Educational attainment

Reaching the minimum school leaving age (16 years) was associated with lower D_1MFT scores among females ($p = 0.049$) where, on average, scores were around 3 units lower (Table 4.10). There was some evidence for a similar association between education and D_3MFT scores ($p = 0.064$) (Table 4.11). Educational attainment was not associated with either caries outcomes (D_1MFT or D_3MFT) in the adult males or male young offenders although the observed effect was in the same direction (i.e. coefficients indicated lower caries scores for those who met school leaving age). The findings are supported by the caries scores for each of the three populations (see Table 4.12).

4.6.2.2 Family circumstances

There was some evidence, although not significant at $p < 0.05$, that female prisoners who were married or cohabiting typically had lower D_1MFT (β = -4.01 (95% CI -8.06, 0.03), $p = 0.052$) and D_3MFT (β = -3.84 (95% CI -7.98, 0.29), $p = 0.068$) scores, when compared with females who were single. Male young offenders with a partner had lower D_3MFT scores (β = -1.99 (95% CI -4.07, 0.09), $p = 0.060$), when compared to those who were single.

Female prisoners without children had significantly lower mean D_1MFT scores (β = -4.67 (95% CI -9.25, -0.09), $p = 0.046$); see Table 4.12 for mean and median values. There was some evidence to suggest that, for females who *were* parents, those sharing residence with their child(ren) had significantly lower D_1MFT scores (β = -3.80 (95% CI -8.18, 0.59), $p = 0.089$) when compared to those living in separate residences. For D_3MFT scores the difference between resident and non-resident mothers was not significant ($p = 0.140$). Resident fathers, among the adult male population, compared with others, also had lower mean scores for D_1MFT and D_3MFT (Table 4.12) although this difference was not significant for either dental score (D_1MFT $p = 0.463$; D_3MFT $p = 0.422$).

4.6.2.3 Living circumstances

Among the female and adult long-stay male populations, having been homeless and longer periods of homelessness were both significantly associated with higher D_1MFT (Table 4.10, page 124) and D_3MFT dental scores (Table 4.11, page 126). The predictive effect of these measures was particularly evident among adult males since the effect sizes were largest, p-values lowest and, as shown in Table 4.12 (page 132), average scores differed the most between the groups of comparison.

For other measures of living circumstances considered, adult males were the only population to have significantly higher dental scores associated with being placed 'in care'
(D_1MFT β = 3.75 (95% CI 1.22, 6.28), $p = 0.004$; D_3MFT β = 4.06 (95% CI 1.54, 6.58), $p = 0.002$). Similarly, adult males living in non-stable accommodations (e.g. temporary or homeless) had significantly greater caries experience when compared to those in more stable living environments ($p = 0.001$ for both caries outcomes) with an average of 6 more teeth affected. See Table 4.10 and Table 4.11 for exact β-coefficients and Table 4.12 for median scores for each population of study.

4.6.2.4 Prison experiences

Time imprisoned showed some association with higher D_3MFT scores in the overall study population ($\beta = 0.16$ (95% CI -0.02, 0.34)) however this finding was not significant at the 5% level ($p = 0.078$); no significant difference or larger effect was determined for time imprisoned and caries scores among the separate prisoner populations.

Similarly, length of stay (less than 4 years, or more than 4 years) was not significantly predictive for either caries scores in the separate prison populations (see Table 4.10 and Table 4.11 for D_1MFT and D_3MFT test results and Table 4.12 for average D_1MFT and D_3MFT scores).

In the separate prison population analyses, female prisoners who had more history of prior remands had significantly greater mean scores for D_1MFT ($\beta = 0.69$ (95% CI 0.11, 1.26), $p = 0.021$) and D_3MFT scores ($\beta = 0.71$ (95% CI 0.08, 1.34), $p = 0.028$). Similarly, for number of prior sentenced stays in prison, female prisoners who had more sentenced stays had higher D_1MFT ($\beta = 0.66$ (95% CI 0.24, 1.07), $p = 0.002$) and D_3MFT ($\beta = 0.72$ (95% CI 0.29, 1.15), $p = 0.001$) scores. For young males a significant relationship was also determined for number of sentenced stays however the direction was reversed i.e. more sentenced stays were associated with lower scores (D_1MFT $\beta = -0.56$ (95% CI -1.06, -0.06), $p = 0.028$; D_3MFT $\beta = -0.60$ (95% CI -1.12, -0.09), $p = 0.023$). It is important to consider that the young offenders reported prior sentences ranging from 0 to 10 however the mode was 1 sentenced stay; in total less than ten young offenders had been sentenced five or more times.

Table 4.12 Descriptives for socio-demographics and caries experience stratified by prison

Potential risk indicator	Females		Long-stay adult males		Male young offenders	
	Mean (*SD*)	Median (25th, 75th %iles)	Mean (*SD*)	Median (25th, 75th %iles)	Mean (*SD*)	Median (25th, 75th %iles)
Caries white spot lesions (D_1MFT)						
Attained education						
Met minimum school leaving age (≥ 16 yrs)	12.66 (6.95)	12 (8, 17)	13.13 (7.21)	13 (8, 18)	7.98 (4.41)	8 (5, 11)
Early school leaver (< 16 yrs)	13.11 (8.15)	13 (6, 19)	14.57 (7.26)	13 (9, 20)	8.20 (5.07)	8 (5, 11)
Employment						
Unemployed/ unable to work	11.00 (7.33)	10 (5, 15)	12.29 (6.90)	11 (7, 15)	8.07 (5.34)	8 (3, 11)
Employed/ education	13.60 (7.61)	13 (7, 19)	14.52 (7.20)	14 (9, 20)	8.12 (4.54)	8 (5, 11)
Standard occupational position						
Managerial & professional	17.67 (8.96)	13 (12, -)	-	-	-	-
Intermediate	11.29 (6.55)	10 (5, 15)	10.85 (6.71)	9 (7, 13)	10.45 (5.28)	10 (8, 15)
Routine & manual	8.38 (7.15)	7 (3, 14)	12.64 (6.68)	12 (9, 16)	8.78 (4.02)	10 (5, 11)
Family & living circumstances						
Marital status						
Single	12.90 (7.61)	12 (7, 17)	13.68 (7.10)	12 (9, 18)	8.09 (4.70)	8 (5, 11)
Married, cohabiting	12.75 (5.15)	15 (7, 16)	14.58 (6.71)	14 (13, 20)	7.00 (3.46)	8 (4, 10)
Separated, divorced, widowed	15.57 (8.92)	14 (10, 22)	16.22 (9.72)	19 (8, 25)	-	-
Shared residence with child(ren)						
No (non-resident parent)	17.33 (8.52)	17 (13, 26)	15.25 (7.13)	14 (11, 21)	6.92 (5.28)	8 (2, 11)
Yes (resident parent)	11.89 (5.68)	11 (8, 16)	13.36 (7.14)	13 (7, 18)	8.50 (3.11)	9 (6, 12)
Has no child	9.69 (6.38)	9 (5, 12)	15.05 (8.74)	12 (7, 24)	8.08 (4.83)	8 (5, 11)
Non-stable accommodation						
Accommodation just prior to prison						
Stable	13.09 (7.28)	13 (8, 17)	12.98 (6.63)	12 (8, 17)	8.13 (4.79)	8 (5, 11)
Non-stable	12.74 (8.82)	11 (6, 20)	20.86 (6.97)	23 (15, 28)	7.75 (5.03)	8 (4, 11)
Ever homeless						
No	12.42 (5.52)	12 (9, 15)	12.35 (6.13)	12 (8, 16)	8.20 (4.30)	8 (5, 11)
Yes	13.20 (8.68)	12 (6, 20)	17.23 (8.38)	18 (11, 25)	7.69 (5.64)	7 (4, 10)

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Potential risk indicator	Females		Long-stay adult males		Male young offenders	
	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)
Length of homelessness						
Less than 6 months	9.93 (6.68)	9 (5, 13)	13.15 (7.69)	12 (7, 19)	7.86 (6.10)	8 (5, 9)
Between 6 months-1year	14.47 (10.41)	10 (5, 27)	18.00 (7.48)	19 (11, 25)	8.11 (6.92)	5 (3, 15)
Between 1-2 years	13.23 (7.19)	14 (7, 17)	19.00 (8.90)	22 (14, 26)	8.43 (2.64)	8 (6, 11)
More than 2 years	15.91 (9.80)	15 (6, 28)	27.00 (1.73)	28 (25, -)	2.00 (2.83)	2 (0, -)
Ever placed 'in care'						
No	12.47 (6.61)	12 (8, 17)	12.80 (6.81)	12 (8, 17)	7.79 (4.57)	8 (5, 11)
Yes	12.86 (8.91)	11 (5, 20)	16.20 (7.32)	16 (10, 21)	8.00 (5.00)	7 (5, 11)
Expected length of stay in prison						
Less than 4 years	12.14 (7.49)	11 (6, 17)	13.75 (9.64)	10 (8, 24)	7.86 (4.77)	7 (5, 11)
More than 4 years	14.76 (6.46)	14 (11, 20)	13.65 (7.17)	13 (8, 19)	10.33 (5.00)	10 (8, 15)
Caries into dentine (D_3MFT)						
Attained education						
Met minimum school leaving age (≥ 16 yrs)	12.02 (7.40)	12 (5, 17)	12.72 (7.25)	12 (7, 17)	5.84 (4.06)	6 (3, 8)
Early school leaver (< 16 yrs)	12.02 (8.47)	11 (5, 18)	13.80 (7.41)	12 (8, 20)	6.48 (4.77)	5 (3, 9)
Employment						
Unemployed/ unable to work (0)	9.84 (7.38)	10 (4, 14)	11.73 (7.11)	10 (7, 14)	6.63 (5.20)	6 (3, 10)
Employed/ education (1)	12.82 (8.06)	12 (6, 18)	13.92 (7.24)	13 (9, 18)	6.01 (4.13)	5 (3, 8)
Socio-economic position						
Managerial & professional	17.67 (8.96)	13 (12, -)	-	-	-	-
Intermediate	9.86 (5.27)	10 (5, 15)	10.23 (7.10)	9 (6, 13)	8.00 (5.35)	7 (4, 10)
Routine & manual	7.00 (7.60)	5 (1, 12)	12.29 (6.73)	11 (9, 16)	7.89 (3.92)	8 (4, 11)
Family & living circumstances						
Marital status						
Single	11.87 (8.03)	11 (5, 17)	13.00 (7.18)	11 (8, 16)	6.16 (4.32)	5 (3, 8)
Married, cohabiting	12.50 (5.16)	15 (7, 16)	14.00 (6.77)	13 (11, 18)	4.17 (2.40)	4 (3, 6)
Separated, divorced, widowed	15.57 (8.92)	14 (10, 22)	16.11 (9.58)	19 (8, 25)	-	-

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Potential risk indicator	Females		Long-stay adult males		Male young offenders	
	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)
Shared residence with child(ren)						
No (non-resident parent)	16.83 (8.83)	17 (12, 26)	14.86 (7.37)	13 (10, 21)	5.85 (5.21)	7 (1, 9)
Yes (resident parent)	11.63 (5.61)	11 (8, 15)	12.82 (7.04)	12 (7, 18)	6.50 (3.42)	6 (4, 10)
Has no child	8.31 (6.36)	7 (4, 12)	14.43 (8.76)	12 (7, 24)	5.94 (4.30)	5 (3, 8)
Non-stable accommodation						
Accommodation just prior to prison						
Stable	12.35 (7.57)	12 (5, 17)	12.38 (6.70)	11 (7, 16)	6.08 (4.45)	5 (3, 8)
Non-stable	11.42 (9.54)	7 (4, 20)	20.21 (7.23)	21 (14, 28)	6.67 (4.79)	6 (3, 10)
Ever homeless						
No	12.22 (5.58)	12 (9, 15)	11.69 (6.23)	11 (7, 15)	6.00 (7.08)	5 (3, 8)
Yes	11.89 (9.21)	10 (4, 18)	16.71 (8.40)	17 (9, 25)	6.38 (5.18)	5 (3, 10)
Length of homelessness						
Less than 6 months	8.27 (5.87)	6 (4, 13)	12.62 (7.53)	9 (7, 18)	6.71 (5.33)	7 (3, 8)
Between 6 months-1year	13.47 (11.24)	9 (3, 27)	17.80 (7.66)	19 (11, 25)	6.33 (6.48)	4 (1, 11)
Between 1-2 years	11.77 (8.14)	11 (5, 17)	18.00 (8.83)	21 (13, 25)	7.14 (3.39)	5 (4, 10)
More than 2 years	14.82 (10.57)	15 (5, 28)	27.00 (1.73)	28 (25, -)	1.50 (2.12)	2 (0, -)
Ever placed 'in care'						
No	11.68 (6.89)	11 (6, 16)	12.08 (6.80)	11 (7, 16)	6.29 (4.33)	5 (3, 9)
Yes	12.00 (9.38)	11 (5, 19)	15.77 (7.50)	16 (9, 21)	5.95 (4.78)	5 (3, 8)
Expected length of stay in prison						
Less than 4 years	11.13 (7.84)	10 (5, 16)	13.75 (9.64)	10 (8, 24)	6.18 (4.54)	5 (3, 9)
More than 4 years	14.38 (6.51)	14 (10, 19)	13.00 (7.23)	12 (7, 18)	6.73 (4.80)	6 (3, 8)

* Time imprisoned, number sentences, number of remands were analysed as a continuous variables

4.6.3 Association between health conditions, indication of medicinal-related xerostomia and caries

In this survey a number of health conditions known to share common risk factors with caries experience were assessed by self-report. The data were aggregated and each respondent identified as either having or not having at least one of the health conditions. Adult male prisoners were the only population where those with such a health condition had significantly greater D_1MFT (β = 3.15 (95% CI 0.35, 5.96), p = 0.028) (Table 4.10) and D_3MFT (β = 3.94 (95% CI 1.21, 6.68), p = 0.005) (Table 4.11) scores when compared to those without a health condition with shared common risk factors. There was some evidence of a similar affect for D_1MFT scores among female prisoners (β = 2.54 (95% CI -0.24, 5.32)) although this was not significant at the 5% level (p = 0.072).

Where medicinal-related xerostomia (dry mouth) was indicated, female prisoners had significantly higher caries experience with 3 more teeth typically affected (D_1MFT β = 3.26 (95% CI 0.34, 6.18), p = 0.029; D_3MFT β = 3.46 (95% CI 0.48, 6.44), p = 0.023). The only other significant trend was indicated for total obvious decay experience (D_1MFT) and in male young offenders, however the direction was reversed with those taking a medication with dry mouth potentially indicated as a side effect having lower mean D_1MFT scores (p = 0.078). The finding for young offenders should be interpreted with caution since the observations were small (n = 6) and overall this population was taking fewer prescribed medicines (irrespective of dry mouth indication) – see Figure 4.3, page 98.

The descriptives for both the above potential risk indicator are reported in Table 4.13 and the robust regression for D_1MFT are reported in Table 4.10 and for D_3MFT in Table 4.11.

Table 4.13 Descriptives for health conditions sharing common risk factors, indication of medicinal-related xerostomia, and caries experience, stratified by prison

Potential risk indicator		All prisoners		Females		Long-stay adult males		Male young offenders	
		Mean (*SD*)	Median*	Mean (*SD*)	Median*	Mean (*SD*)	Median*	Mean (*SD*)	Median*
Total obvious decay experience (D_1MFT)									
Common risk factor(s) indicated by health condition(s)	**No**	10.29 (5.65)	10 (7, 13)	11.57 (6.56)	10 (6, 16)	11.39 (5.76)	11 (8, 14)	8.50 (4.47)	8 (5, 11)
	Yes	13.71 (7.77)	13 (7, 19)	14.10 (7.76)	14 (8, 20)	16.86 (7.56)	16 (11, 23)	8.59 (5.19)	7 (5, 12)
Medicinal related xerostomia indicated	**No**	10.78 (6.56)	10 (6, 14)	11.17 (6.81)	10 (6, 15)	13.61 (7.14)	12 (8, 18)	8.27 (4.78)	8 (5, 11)
	Yes	14.18 (7.90)	13 (8, 20)	15.35 (7.95)	15 (9, 22)	14.44 (7.55)	13 (9, 20)	5.50 (4.09)	7 (1, 9)
Caries into dentine (D_3MFT)									
Common risk factors indicated by health condition(s)	**No**	8.86 (5.83)	8 (5, 12)	10.90 (6.90)	10 (6, 15)	10.37 (5.50)	11 (6, 13)	6.24 (4.35)	5 (3, 8)
	Yes	12.94 (8.04)	12 (6, 18)	13.17 (8.07)	13 (5, 18)	16.67 (7.56)	16 (11, 23)	7.21 (4.89)	6 (4, 10)
Medicinal related xerostomia indicated	**No**	9.53 (6.85)	8 (4, 13)	10.15 (7.09)	10 (4, 15)	13.09 (7.26)	11 (7, 18)	6.31 (4.52)	5 (3, 9)
	Yes	13.45 (8.11)	13 (7, 19)	14.70 (8.37)	14 (8, 22)	13.68 (7.55)	13 (8, 19)	4.50 (3.39)	6 (1, 7)

* Median (25^{th}, 75^{th} percentiles)

4.6.4 Association between health risk behaviours and caries

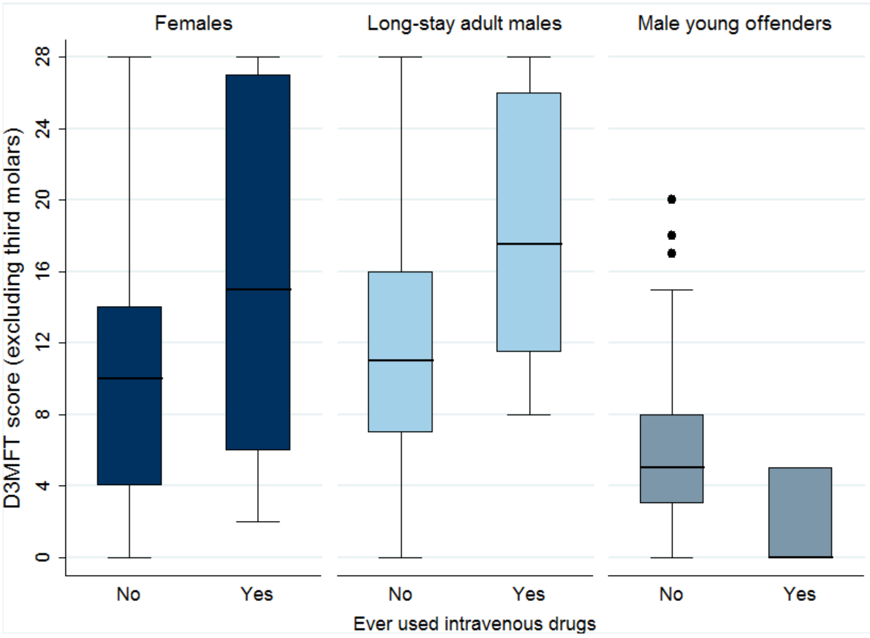
Health risk behaviours were assessed by cigarette smoking, number of cigarettes smoked per day, history of having used an illegal drug, and indicators of more problematic use: intravenous drug use and participation in a drug rehabilitation programme. Almost all these health behaviours were very highly significantly associated with both caries outcomes for the population *overall*, and for *females* and *adult males* when studied by prison population (Table 4.10 & Table 4.11). The average D_1MFT and D_3MFT experience are reported in Table 4.14 on page 139.

Smoking cigarettes was associated with higher caries experience among females ($p < 0.001$ both caries scores) and adult males (D_1MFT $p = 0.005$; D_3MFT $p = 0.006$). The number of cigarettes smoked per day had a slightly bigger effect among females when compared with adult males as evidenced by the larger effect sizes (β-coefficients) – for example, smoking 10 cigarettes per day was associated with an increase of 1.9 in the D_1MFT scores in females compared with an increase of 1.4 in adult males (see Table 4.10, page 124). Findings for D_3MFT are shown in Table 4.11 (page 126).

In both females and adult males, IDU was associated with higher D_1MFT and D_3MFT scores. For a given age, females reporting IDU had mean scores on average 7 unit higher when compared to those not reporting IDU (D_1MFT $\beta = 7.06$ (95% CI 3.99, 10.12); D_3MFT $\beta = 7.37$ (95% CI 4.25, 10.49)). Adult males, reporting IDU, at a given age, also had higher mean scores which were on average 5 units higher (D_1MFT $\beta = 4.89$ (95% CI 1.72, 8.06); D_3MFT $\beta = 4.96$ (95% CI 1.71, 8.21)). For both females and adult males, the median scores were higher in those reporting IDU when compared to those who had not used intravenous drugs (Figure 4.11); the dental scores for female IDUs were more skewed toward the higher end of the scoring range. Only three male young offenders had used intravenous drugs therefore it was not possible to estimate the effect size for caries reliably for this population (i.e. the corresponding p-values were not taken as reliable estimates of effect of IDU in this sub-population).

Problematic drug use, as indicated by participation in a rehabilitation programme, was significantly associated with both caries outcomes, among females (D_1MFT $p = 0.004$; D_3MFT $p = 0.003$) and adult males (D_1MFT $p = 0.061$; D_3MFT $p = 0.049$), when compared to those who had not taken part in such a programme. The relationship between having taken part in rehabilitation and caries was again stronger for females, when compared with adult males, (D_1MFT $\beta = 4.87$ vs $\beta = 2.90$; D_3MFT $\beta = 5.20$ vs $\beta = 3.08$).

Any (illegal) drug use was also strongly associated with both outcomes for females and adult males (see Table 4.10 and Table 4.11 for results). Whilst the association is not as large as IDU it is noted 23% of the respondents using *any* drugs were also included in the related intravenous measure.



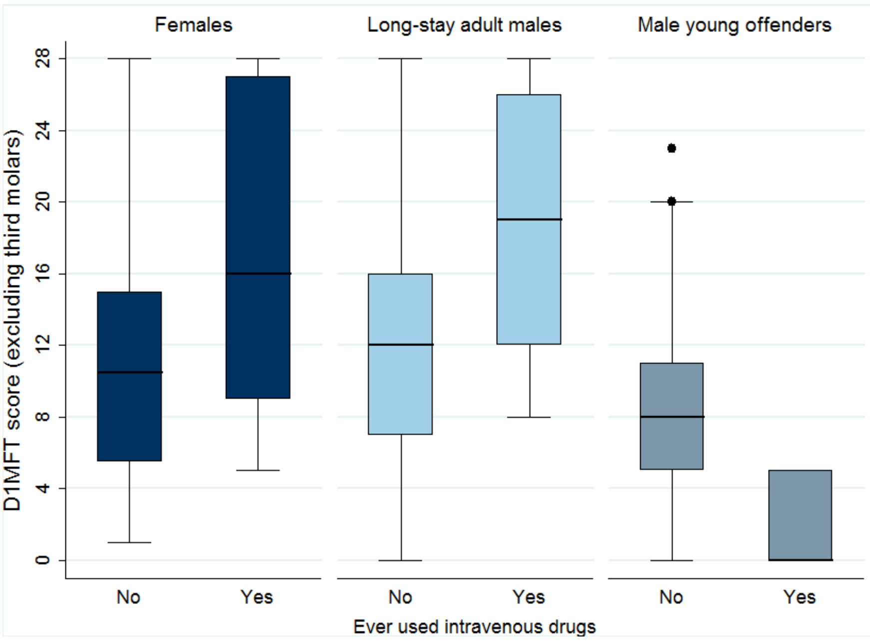


Figure 4.11 Distribution of D_1MFT and D_3MFT scores for intravenous drug use by prison

Table 4.14 Descriptives for health risk behaviours and caries experience stratified by prison

Potential risk indicator	Total obvious decay experience (D_1MFT)						Caries into dentine (D_3MFT)					
	Females		Long-stay adult males		Male young offenders		Females		Long-stay adult males		Male young offenders	
	Mean (*SD*)	Median*	Mean (*SD*)	Median*	Mean (*SD*)	Median*	Mean (*SD*)	Median*	Mean (*SD*)	Median*	Mean (*SD*)	Median*
Smokes cigarettes**												
No	9.21 (6.75)	9 (3, 14)	11.32 (6.01)	11 (7, 15)	8.58 (5.64)	8 (4, 14)	8.42 (7.10)	5 (2, 14)	10.74 (6.08)	11 (6, 15)	7.11 (4.93)	7 (4, 10)
Yes	13.66 (7.34)	12 (8, 19)	14.86 (7.52)	13 (9, 21)	7.99 (4.57)	8 (5, 11)	12.84 (7.85)	12 (6, 18)	14.25 (7.60)	13 (9, 20)	5.99 (4.35)	5 (3, 8)
(Illegal) drug use												
No	11.00 (7.11)	11 (5, 16)	13.09 (7.85)	13 (8, 18)	7.00 (5.83)	8 (0, 11)	10.03 (7.48)	10 (3, 16)	12.27 (8.16)	11 (7, 17)	5.71 (4.50)	7 (0, 10)
Yes	13.56 (7.53)	12 (8, 19)	13.95 (6.78)	13 (9, 19)	8.12 (4.77)	8 (5, 11)	12.71 (7.90)	12 (6, 18)	13.39 (6.76)	12 (9, 18)	6.19 (4.55)	5 (3, 8)
Intravenous drug use												
No	10.89 (6.36)	11 (5, 15)	12.54 (6.45)	12 (7, 16)	8.20 (4.81)	8 (5, 11)	10.00 (6.50)	10 (4, 14)	11.89 (6.428)	11 (7, 16)	6.23 (4.49)	5 (3, 8)
Yes	16.67 (8.42)	16 (9, 27)	18.70 (6.94)	19 (12, 27)	1.67 (2.89)	0 (0, -)	15.89 (9.21)	15 (6, 27)	18.20 (7.19)	18 (11, 27)	1.67 (2.89)	0 (0, -)
Participated in drug rehabilitation programme												
No	11.60 (6.60)	12 (6, 16)	13.18 (6.87)	12 (8, 18)	8.13 (4.87)	8 (5, 11)	10.65 (6.88)	11 (5, 15)	12.53 (6.93)	11 (7, 17)	6.20 (4.57)	5 (3, 8)
Yes	15.81 (8.34)	14 (9, 25)	16.96 (7.69)	15 (11, 26)	7.71 (3.40)	8 (5, 12)	15.08 (8.91)	14 (7, 25)	16.54 (7.75)	15 (11, 25)	6.29 (2.93)	6 (4, 7)

*Median (25^{th}, 75^{th} percentiles); **Number of cigarettes smoked per day analysed separately as a continuous variable

4.6.5 Association between dental health-related behaviours and caries

Dental health-related behaviours assessed in this study included attendance at a prison dentist, preventive dental treatments received, time since last dental attendance (inside or outside prison), and whether respondents brushed their teeth with fluoride toothpaste, and avoided sugar consumption between meals (at home and in prison). The mean and median dental scores for these behaviours are reported in Table 4.15 over the page.

Time since last dental attendance was not associated with either D_1MFT (Table 4.10) or D_3MFT (Table 4.11) scores for any of the populations studied. The toothbrushing and sugar consumption behaviours, whilst in the *prison* setting, were also not significantly associated with either caries outcome scores. When in the home setting, avoiding sugars between meals was significantly associated with lower D_3MFT scores among adult males (β = -2.56 (95% CI -5.04, -0.08), p = 0.043). Additionally, amongst adult males, there was some evidence that toothbrushing with fluoride toothpaste was associated with lower D_3MFT scores (β = -2.25 (95% CI -4.63, 0.14), p = 0.065), and the sugar-related behaviour was associated with lower D_1MFT scores (β = -2.40 (95% CI -4.91, 0.11), p = 0.061). Neither behaviours were associated with caries outcomes among females or male young offenders.

With regard to attendance for a preventive dental treatments, adult males again had improved caries experience if they had a history of receiving such treatments although this was only significant for severe caries into dentine (D_1MFT β = -2.87 (95% CI -6.03, 0.30), p = 0.075; D_3MFT β = -3.21 (95% CI -6.30, -0.13), p = 0.041). Attendance for preventive dental treatment was not associated with caries scores among females or male young offenders (see Table 4.10 for D_1MFT and Table 4.11 for D_3MFT).

As to be expected, having seen a prison dentist was related to higher scores for both caries outcomes (as evidenced by the positive coefficients) the difference between those who had and had not attended were not significant at the 5% level with the exception of D_3MFT scores for adult males (β = 2.89 (95% CI 0.44, 5.33), p = 0.021). Although, there was further evidence of possible association with dental attendance for D_3MFT scores among females (β = 2.67 (95% CI -0.46, 5.80), p = 0.093) (Table 4.10), and for D_1MFT scores among adult males (β = 2.22 (95% CI -0.37, 4.80), p = 0.092) and male young offenders (β = 1.79 (95% CI -0.32, 3.89), p = 0.095) (Table 4.11).

Table 4.15 Descriptives for dental health-related behaviours and caries experience stratified by prison

Potential risk indicator	Females		Long-stay adult males		Male young offenders	
	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)
Total obvious decay experience (D_1MFT)						
Ever attended prison dentist						
No	11.31 (6.89)	10 (6, 15)	11.93 (7.19)	12 (7, 15)	7.53 (4.72)	7 (4, 11)
Yes	15.23 (7.74)	14 (9, 21)	14.51 (7.17)	13 (9, 20)	9.30 (4.76)	8 (6, 14)
Attended for preventive dental treatment*						
No	10.20 (7.21)	8 (5, 17)	17.44 (8.46)	15 (12, 28)	8.21 (4.48)	7 (5, 11)
Yes	14.12 (7.50)	14 (9, 20)	13.05 (5.81)	13 (9, 18)	8.02 (4.44)	8 (5, 11)
Time since last dental attendance						
< 6mth	13.97 (7.30)	13 (9, 20)	13.52 (7.10)	14 (7, 20)	8.13 (4.51)	8 (5, 11)
6mth-1yr	13.31 (9.13)	12 (6, 21)	12.29 (6.21)	11 (7, 15)	9.25 (4.51)	9 (7, 13)
1-2yrs	12.16 (7.39)	12 (6, 17)	14.27 (6.42)	13 (10, 18)	8.00 (5.62)	6 (5, 11)
2-5yrs	11.13 (5.06)	11 (7, 14)	14.00 (7.95)	12 (9, 21)	8.29 (4.45)	8 (5, 12)
> 5yrs	11.00 (7.98)	9 (5, 15)	16.13 (11.22)	16 (6, 28)	5.55 (2.62)	7 (4, 7)
Never attended	10.50 (13.44)	11 (1, -)	-	-	7.67 (7.51)	8 (0, -)
Brushed teeth with fluoride toothpaste						
At Home						
No/Missing	12.64 (7.22)	13 (7, 15)	16.16 (7.20)	15 (11, 22)	8.81 (5.50)	8 (5, 13)
Yes	12.92 (7.63)	12 (6, 18)	12.00 (6.78)	11 (7, 16)	7.91 (4.57)	8 (5, 11)
In Prison						
No/ Missing	12.42 (7.95)	12 (6, 19)	16.70 (11.95)	20 (2, 28)	7.64 (4.46)	8 (4, 11)
Yes	12.96 (7.53)	12 (7, 17)	13.59 (6.62)	13 (9, 18)	8.16 (4.83)	8 (5, 11)
Avoided sugars between meals						
At Home						
No/Missing	12.23 (6.76)	12 (8, 16)	14.56 (7.46)	13 (9, 20)	8.62 (4.69)	8 (5, 11)
Yes	13.60 (8.34)	12 (6, 21)	11.14 (5.68)	11 (7, 16)	6.97 (4.81)	6 (4, 11)
In Prison						
No/Missing	12.85 (7.54)	12 (7, 17)	14.19 (7.86)	13 (8, 20)	7.68 (4.24)	8 (5, 10)
Yes	12.94 (7.66)	12 (5, 19)	13.43 (6.35)	13 (9, 18)	8.94 (5.65)	7 (5, 14)

Potential risk indicator	Females		Long-stay adult males		Male young offenders	
	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)	Mean (*SD*)	Median (25^{th}, 75^{th} %iles)
Caries into dentine (D_3MFT)						
Ever attended prison dentist						
No	10.21 (4.41)	10 (4, 15)	10.83 (7.14)	11 (7, 14)	5.88 (4.40)	5 (3, 8)
Yes	14.65 (7.86)	14 (9, 20)	14.10 (7.21)	13 (9, 20)	6.77 (4.60)	6 (4, 8)
Attended for preventive dental treatment*						
No	9.10 (7.56)	8 (2, 15)	17.19 (8.42)	14 (12, 28)	6.42 (4.53)	4 (3, 10)
Yes	13.54 (7.73)	13 (8, 18)	12.37 (5.80)	12 (8, 17)	6.16 (3.98)	6 (4, 8)
Time since last dental attendance						
< 6mth	13.15 (7.73)	13 (7, 18)	13.00 (6.99)	13 (7, 18)	5.78 (4.58)	5 (3, 8)
6mth-1yr	13.00 (9.19)	12 (5, 20)	12.00 (6.01)	11 (7, 15)	6.75 (4.00)	7 (3, 8)
1-2yrs	11.16 (7.88)	10 (4, 17)	13.52 (6.57)	13 (9, 17)	6.74 (4.95)	6 (4, 9)
2-5yrs	10.25 (5.09)	10 (6, 13)	13.14 (8.36)	11 (8, 21)	6.43 (5.16)	5 (2, 10)
> 5yrs	9.13 (8.43)	8 (3, 11)	16.00 (11.25)	16 (6, 28)	4.00 (1.90)	4 (3, 5)
Never attended	10.50 (13.44)	11 (1, -)	-	-	6.00 (5.57)	7 (0, -)
Brushed teeth with fluoride toothpaste						
At Home						
No/Missing	12.45 (7.03)	13 (7, 15)	15.78 (7.35)	14 (11, 21)	6.10 (5.21)	4 (3, 9)
Yes	11.96 (8.08)	11 (5, 17)	11.23 (6.69)	10 (6, 14)	6.23 (4.28)	6 (3, 8)
In Prison						
No/ Missing	11.50 (8.13)	11 (5, 17)	16.50 (12.22)	20 (1, 28)	5.45 (3.86)	4 (3, 10)
Yes	12.10 (7.94)	12 (5, 17)	12.95 (6.65)	12 (8, 17)	6.30 (4.54)	5 (3, 8)
Avoided sugars between meals						
At Home						
No/Missing	11.51 (7.14)	11 (5, 16)	14.01 (7.51)	13 (9, 20)	6.49 (4.33)	6 (4, 9)
Yes	12.58 (8.75)	11 (5, 19)	10.36 (5.77)	10 (6, 13)	5.58 (4.75)	4 (2, 7)
In Prison						
No/Missing	12.17 (7.86)	11 (6, 17)	13.54 (7.90)	13 (7, 20)	5.86 (3.98)	5 (3, 8)
Yes	11.81 (8.12)	12 (5, 17)	12.91 (6.51)	12 (8, 18)	6.88 (5.31)	6 (3, 10)

* Scale and polish, fissure sealant, or fluoride treatment

4.6.6 Association between dental health-related attitudes and caries

The three dental health-related attitudes included in this study were: reason for last dental attendance, and treatment preferences for front tooth (crown, or extraction) and back tooth (fillings, or extraction). Without exception, all attitudinal measures were significantly and strongly associated with both total obvious decay experience (D_1MFT) and more severe caries into dentine (D_3MFT) however these significant findings were limited to the female population (Table 4.10 and Table 4.11 for associations by prison population, for D_1MFT and D_3MFT respectively).

Amongst females, last dental attendance significantly predicted both caries outcome scores where attendance for a routine check-up was associated with lower D_1MFT (β = -4.07 (95% CI -6.75, -1.40), $p = 0.003$), and D_3MFT (β = -3.77 (95% CI -6.49, -1.04), $p = 0.007$) scores (mean values of 9.54 and 8.81 respectively), when compared to those who attended with difficulties (means of 13.33 and 12.23 respectively). The mean and median values for all three populations are reported in Table 4.16.

Similarly, amongst females, those who preferred extraction for a front tooth requiring treatment (rather than restorative dental treatment) had significantly higher mean dental caries scores (D_1MFT β = 6.45 (95% CI 1.61, 11.28), $p = 0.010$; D_3MFT β = 6.46 (95% CI 1.16, 11.76), $p = 0.018$). For back teeth, females preferring extraction had higher dental scores (β = 4.22 (95% CI 1.28, 7.17), $p = 0.006$; β = 4.13 (95% CI 1.07, 7.19), $p = 0.009$ respectively), when compared to those preferring restorative treatment. As shown in Table 4.10 dental treatment preferences were not significantly associated with D_1MFT mean scores among adult males and male young offenders; the equivalent findings for D_3MFT mean scores are reported in Table 4.11.

Table 4.16 Descriptives for dental health-related attitudes and caries experience stratified by prison

Potential risk indicator	Females		Long-stay adult males		Male young offenders	
	Mean (*SD*)	Median*	Mean (*SD*)	Median*	Mean (*SD*)	Median*
Total obvious decay experience (D_1MFT)						
Reason for last dental attendance						
Check-up	9.54 (6.54)	8 (5, 14)	14.44 (6.56)	15 (10, 19)	7.33 (3.88)	8 (5, 10)
Trouble with teeth or gums	13.33 (6.71)	13 (9, 17)	13.69 (7.09)	12 (8, 20)	8.59 (4.83)	8 (5, 11)
Other reason	13.67 (6.81)	16 (6, -)	11.67 (11.06)	13 (0, -)	7.23 (3.86)	7 (5, 11)
Treatment preferences: aching back tooth						
Filled	11.00 (6.72)	10 (6, 15)	13.42 (6.50)	13 (9, 18)	8.28 (4.83)	8 (5, 11)
Extracted	16.28 (7.66)	15 (10, 22)	14.57 (8.68)	12 (8, 23)	7.23 (4.62)	7 (4, 10)
Treatment preferences: front tooth requiring extraction						
Crowned	12.08 (6.39)	12 (7, 16)	13.43 (6.47)	12 (9, 18)	7.88 (4.66)	8 (5, 11)
Extracted	19.45 (9.06)	20 (13, 28)	15.00 (10.86)	16 (5, 27)	9.82 (5.71)	10 (5, 16)
Caries into dentine (D_3MFT)						
Reason for last dental attendance						
Check-up	8.81 (7.11)	7 (4, 14)	13.75 (6.39)	13 (10, 19)	5.33 (2.83)	6 (3, 7)
Trouble with teeth or gums	12.23 (7.15)	12 (6, 17)	13.06 (7.17)	11 (7, 18)	6.52 (4.67)	6 (3, 10)
Other reason	12.67 (6.81)	15 (5, -)	11.67 (11.06)	13 (0, -)	5.54 (3.23)	6 (4, 8)
Treatment preferences: aching back tooth						
Filled	10.10 (6.83)	10 (5, 14)	12.78 (6.56)	12 (8, 18)	6.35 (4.44)	6 (4, 8)
Extracted	15.50 (8.41)	15 (9, 22)	14.07 (8.75)	11 (7, 23)	5.55 (4.60)	4 (3, 9)
Treatment preferences: front tooth requiring extraction						
Crowned	11.14 (6.68)	11 (5, 15)	12.77 (6.50)	12 (8, 17)	6.04 (4.29	5 (3, 8)
Extracted	18.73 (10.16)	20 (10, 28)	14.83 (10.96)	15 (5, 27)	7.64 (5.87)	7 (3, 11)

* Median (25^{th}, 75^{th} percentiles)

4.6.7 Association between psychosocial health and caries

Both psychosocial measures (CES-D depression score, and MDAS dental anxiety score) were assessed as continuous measures.

There was no relationship between the CES-D depression score and D_1MFT (see Table 4.10) or D_3MFT (see Table 4.11) scores among females, long-stay adult males and male young offenders.

For the whole study population, dental anxiety had a weak and significant association with both D_1MFT ($\beta = 0.15$ (95% CI 0.02, 0.27), $p = 0.023$) and D_3MFT ($\beta = 0.13$ (95% CI 0.01, 0.26), $p = 0.041$) mean scores. However, when examined by prison, the dental anxiety (MDAS) score was only significantly associated with the caries outcomes in the male young offenders population (D_1MFT $\beta = 0.21$ (95% CI 0.02, 0.40), $p = 0.027$; D_3MFT $\beta = 0.21$ (95% CI 0.02, 0.41), $p = 0.033$). Table 4.10 reports the associations between this potential risk indicator and D_1MFT scores for each population and Table 4.11 reports the equivalent for D_3MFT scores. The relationship between MDAS and dental scores is illustrated in Figure 4.12.

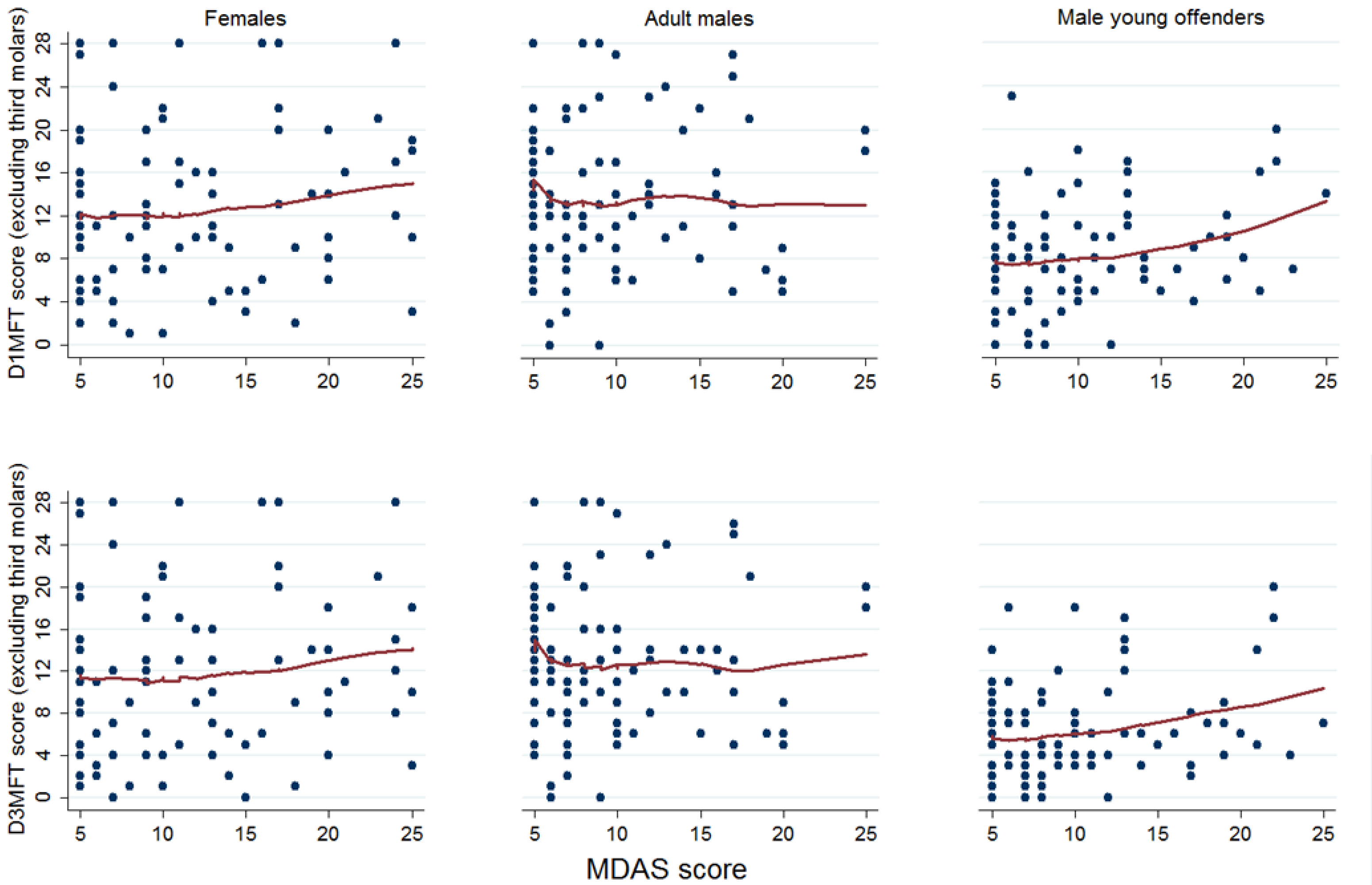


Figure 4.12 **Lowess plots of MDAS (dental anxiety) scores and D_1MFT and D_3MFT caries scores**

Summary of relationship between risk indicators and caries outcomes

- Age was positively associated with caries with 32% of total caries and 39% of caries into dentine scores explained respectively.
- Among adults, there was little evidence gender on its own explained variation in caries experience. There was some limited evidence, in the total study population (i.e. including those < 21 years of age), that females had significantly higher caries into dentine scores.
- Neither unemployment nor the social economic occupational position measures predicted caries in the three prison populations studied.
- Female prisoners who stayed in education for 16 years had on average 3 fewer teeth with caries. Educational attainment did not significantly explain caries experience in the long-stay adult male or male young offender populations.
- There was some limited evidence ($p < 0.1$) that family circumstances were an important risk indicator of caries among females: those who were single had higher caries scores, when compared to those married or with a partner; mothers living in separate residencies from their children had higher total obvious decay experience, when compared with resident mothers.
- History of homelessness, and longer periods of homeless were significantly associated with higher caries scores in long stay adult male and female prisoners. The predictive effect of homelessness was particularly evident among adult males since the effect sizes were larger and more significant.
- Having been placed in a children's institution or foster home was additionally associated with higher caries scores among long-stay adult males. Furthermore, adult males reporting 'non-stable' accommodations just prior to imprisonment had significantly higher caries experience.
- Time spent in prison was only associated with caries into dentine scores and for all prisoners combined. For females, multiple stays in prison either remanded or sentenced, was significantly associated with slightly higher caries scores.
- Adult males with a health condition known to share common risk factors with caries had higher caries experience and, in the case of severe caries into dentine, on average had 4 more teeth affected. There was some evidence of a similar effect for total obvious caries experience among females.
- Taking medicines with dry mouth potentially indicated as a side effect was associated with having 3 more teeth with caries among females.
- All the health risk behaviours (smoking, number cigarettes, drug use, intravenous drug use and participation in drug rehabilitiation programme) were significantly associated with higher caries scores among females and long-stay adult males.

- Smoking cigarettes appears to have bigger effect among female prisoners, when compared with adult males, as evidenced by larger effect sizes. The relationship between intravenous drug use and drug rehabilitation was similarly stronger for females, when compared with adult males.
- Since few male young offenders had used intravenous drugs, it was not possible to estimate the effect sizes for caries reliably for this population.
- A number of dental specific behaviours (time since last dental attendance, toothbrushing with fluoride toothpaste and avoidance of sugars between meals *in the prison* setting) showed no association with either caries outcomes.
- Amongst long-stay adult males there was some evidence the toothbrushing and sugar avoidance behaviours were associated with caries in the context of the *home* environment, with positive behaviours associated with less caries experience. Furthermore, adults males who had attended for a preventive dental treatment had significantly lower caries into dentine scores.
- As to be expected, there was some evidence having seen a prison dentist was associated with higher scores across all three populations surveyed, although prison dental attendance was only significant for caries into dentine scores among long-stay adult males.
- For dental health-related attitudes, females who last attended for a check-up had significantly lower caries scores when compared to those attending with problems, and females who indicated a preference for extraction (rather than restorative treatment) had significantly higher caries scores. No significant differences were determined for dental related attitudes and caries experience among long-stay adult males and male young offenders.

4.7 Correlations and data reduction to minimize severe multicollinearity between potential risk indicators

At the end of the "univariable" analyses (see section 4.6), from the original list of thirty-two potential risk indicators (excluding age and gender), seven were excluded as they had no significant association with total caries experience (Table 4.10) and caries into dentine (Table 4.11) scores in either all prisoners or any of the individual prison populations. The seven measures with no predictive power for either caries scores were: standard occupation classification (SOC), unemployment, length current stay in prison, time since last dental attendance, avoid sugars between meals in prison, toothbrushing in prison, and the depression (CES-D) score. Additional to the above, for total caries (D_1MFT) scores specifically, one additional measure had no predictive power (toothbrushing at home) and was excluded from further analyses for this (D_1MFT) dental score. Time imprisoned was also not significantly associated with the D_1MFT dental scores, however this was retained as it was relevant when modeling other prison-related risk indicators e.g. attendance at prison dentist. No additional exclusions, specific to caries into dentine scores (D_3MFT), were required.

Before proceeding to the "multivariable" robust regression models, the remaining list of potential risk indicators had to be reviewed in light of the correlations identified (see section 4.5) and with a view to explore any overtly related variables. This step was necessary to reduce the effects of severe multicollinearity which would adversely impact the statistical power of the analyses making it more difficult to specify correctly fitted models. The AIC (an indicator of model goodness of fit) was used to select from variables that were correlated or related. It is important to distinguish that AIC was used as a measure to decide between which risk indicator to examine further in the "multivariable" analyses, however the results from the "univariable" analyses are still valid.

From the measures pertaining to living circumstances, two captured information for an identical concept of homelessness: ever experienced homelessness and length of homelessness experienced and these were strongly correlated in the tests of association ($r_s = 0.958$; see Appendix 9.9.1). The AIC for the "univariable" robust regressions were calculated and for D_1MFT scores this was 1862 for homelessness and 1858 for length of homelessness; for D_3MFT scores a lower AIC was again evident for length of homelessness (1849 versus 1853). Thus, length of homelessness was retained for "multivariable" analyses.

Of the remaining prison experience measures, two were strongly associated with each other: number of prior remands and number of times sentenced (r_s = 0.704). For D_1MFT scores, the AIC for prior sentences was 1209 when compared with a lower AIC of 1208 for number of remands. A similar pattern in AIC values was found for D_3MFT scores, where the model for prior remands had a value of 1202 when compared with 1203 for prior sentences. Thus, number of remands was retained for further analyses.

Since the two concepts of health conditions and medicinal use to treat ailments are closely related (36% in this study population both had such a health condition and medicinal-related dry mouth was indicated), these two parameters (r_s = 0.221) were also assessed. For D_1MFT scores, AIC for health conditions = 1671 and for indication of medicinal-related xerostomia (dry mouth) = 1675; similarly for D_3MFT a lower AIC was evident for health (1664 versus 1671). Thus the health conditions measure was retained for further analyses.

For the health risk behaviours, being a smoker (yes/no) and number of cigarettes smoked per day were correlated (r_s = 0.758). For D_1MFT mean scores, AIC for smoking cigarettes was 1775 and for number cigarettes smoked per day was 1771. For D_3MFT scores a lower AIC was found for the binary smoking measure (1770 versus 1771); the R^2 for the overall models was 0.42 for both smoking-related measures. Since the AIC and R^2 were almost identical for caries into dentine scores, a pragmatic decision was taken to use the findings for D_1MFT and select number of cigarettes smoked per day for further analyses.

In summary, an additional four measures (ever experienced homelessness, number of sentenced stays in prison, indication of medicinal-related xerostomia/dry mouth, and smoking cigarettes) were excluded from the "multivariable" analyses – the process for eliminating the potential risk indicators is overviewed in Figure 4.13 and Table 4.17 lists the risk indicators specified for each multiple regression analyses i.e. for each outcome measure and population of interest.

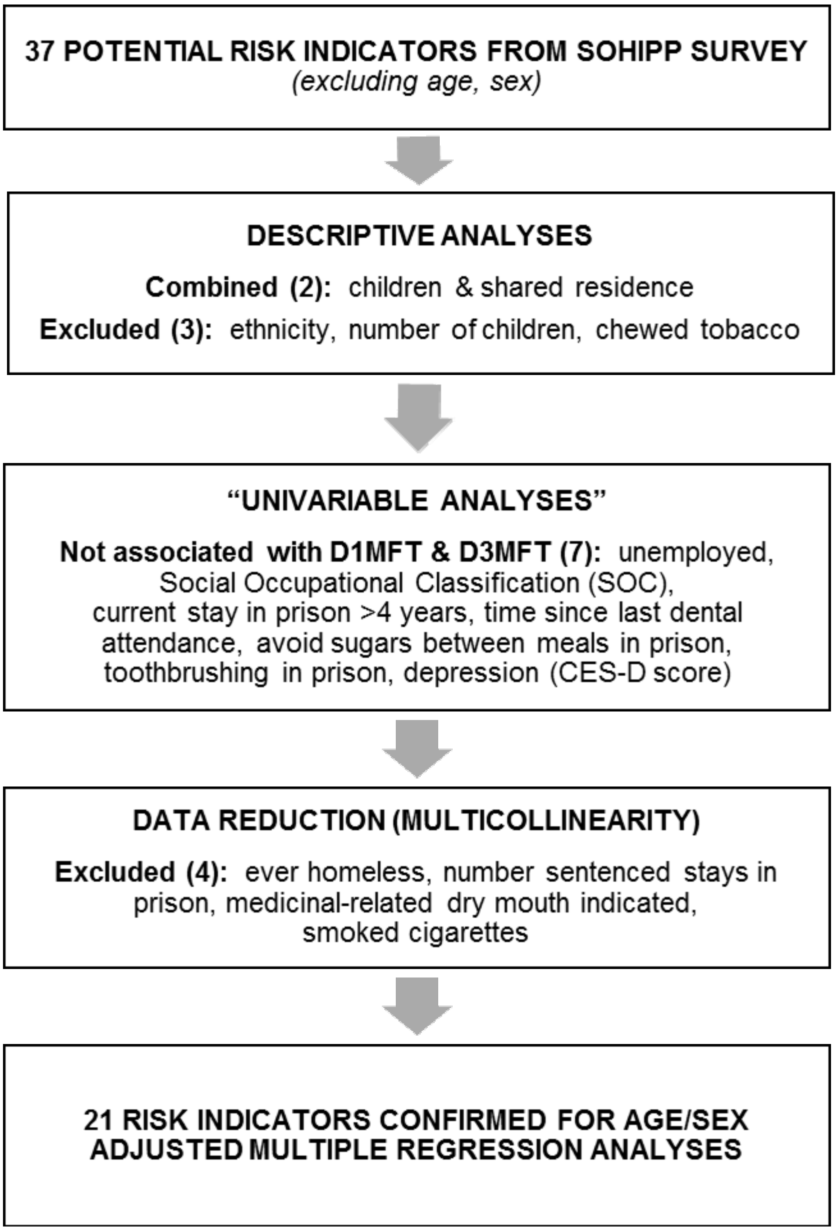


Figure 4.13 Flowchart of potential risk indicators excluded at each step of statistical analyses

Table 4.17 Cross tabulation of final list of potential risk indicators for age (gender) adjusted “multivariable” stepwise robust regression analyses

Theme	Potential risk indicators*	All prisoners		Females**		Long-stay adult males**		Male young offenders**	
		D_1MFT scores	D_3MFT scores	D_1MFT scores	D_3MFT scores	D_1MFT scores	D_3MFT scores	D_1MFT scores	D_3MFT scores
Socio-demographics: education	Completed mandatory education (16 years)	✓	✓	✓	✓				
Socio-demographics: family circumstances	Marital status	✓	✓						✓
	Shared residence with child(ren)				✓	✓	✓		
Socio-demographics: living circumstances	Non-stable living accommodation just prior to imprisonment	✓	✓			✓	✓		
	Length homelessness	✓	✓	✓	✓	✓	✓		
	Placed ‘in care’	✓	✓			✓	✓		
Socio-demographics: prison experiences	Time imprisoned (years)	✓	✓		✓	✓	✓	✓	
	Number of remands			✓	✓				
Common risk factors and health	Health condition(s) with common risk factors	✓	✓	✓		✓	✓		
Health risk behaviours	Number of cigarettes smoked per day	✓	✓	✓	✓	✓	✓		
	Any (illegal) drug use	✓	✓	✓	✓	✓	✓		
	Intravenous drug use	✓	✓	✓	✓	✓	✓		
	Participated drug rehabilitation programme	✓	✓	✓	✓	✓	✓		
Dental health-related behaviours	Attended prison dentist	✓	✓		✓	✓	✓	✓	
	Attended for preventive dental treatment					✓	✓		
	Avoid sugar between meals at home					✓	✓		
	Brushed teeth at home						✓		
Dental health-related attitudes	Reason last dental attendance	✓	✓	✓	✓				
	Prefer extraction back tooth needs filled			✓	✓				
	Prefer extraction front tooth needs crowned	✓	✓	✓	✓				
Psychosocial health	Dental anxiety (MDAS score)	✓	✓					✓	✓

* *p* < 0.1 in univariable robust regression; ** including all risk indicators from reciprocal final multivariable predictive models for all prisoners

Part 3: Multiple regression models for caries experience

Part 3 describes the results from the stepwise multiple regression models ("multivariable" analyses) for both total obvious decay experience (D_1MFT) and caries into dentine (D_3MFT) scores. The final models reported represent the minimal set of risk indicators which best predict D_1MFT or D_3MFT scores in this study population and are reported for all prisoners and separately for each prison population studied i.e. females, (long-stay) adult males and male young offenders.

The risk indicators considered for each multiple regression are listed in Table 4.17. In brief, the indicators listed comprised all those identified as having an important association with the outcome of interest as determined from at least some evidence ($p < 0.10$) of an association with the outcome from the age (and gender for all prisoners) adjusted "univariable" analysis (see section 4.6).

To ensure the indicators entered into the models were not highly correlated, the list from the univariable analysis was further minimized to include only the most informative variables from common sets of closely related variables i.e. those which describe the same essential characteristic, for example retaining homelessness length but excluding ever homeless (see section 4.7). To ensure multicollinearity had been sufficiently addressed, prior to running the multiple regression, the Variance Inflation Factor (VIF) was calculated for the full models including all risk indicators to be investigated. In this study VIF values for all variables in these initial models were much lower than 10, indicating negligible collinearity between the potential risk indicators entered and that the final coefficients could be reported as reasonable estimates of effect size. Note however this does not mean that the risk indicators are not correlated and even moderate associations between the potential risk indicators make the estimates less precise and effectively reduce the sample size making it harder to detect effects and disentangle the independent effect of each risk indicator [163]; thus the findings from non-parametric tests should be considered in the interpretation of the final results.

In the multiple regression models, as applicable all variables listed in Table 4.17 were fitted to an initial model, and then backward and forward stepwise selection used to remove risk indicators which did not significantly explain the variance in outcome scores; cut-off for retention in the final model was $p < 0.20$, however only $p < 0.05$ was considered significant. Where the p-values were greater than 0.05, the AIC was used to assess if removing any of the variables would improve model fit; an improved model was one with a smaller AIC value – indicating best compromise between percentage of variation being explained and a more parsimonious model with fewer parameters.

4.8 Models for D_1MFT and D_3MFT scores: all prisoners

The risk indicators considered for multivariable analysis for all prisoners were the same for both total obvious decay experience (D_1MFT) and caries into dentine (D_3MFT) scores: age, gender, attained mandatory education, marital status, non-stable living accommodation just prior to prison (community), length of homelessness, placed 'in care', time imprisoned (years), health condition with common risk factors, number of cigarettes smoked per day, any (illegal) drug use, intravenous drug use (IDU), drug rehabilitation programme, prison dental attendance, reason for last dental attendance, preferred extraction for front tooth needing crowned, and dental anxiety (MDAS score). Table 4.18 presents the findings for D_1MFT and Table 4.19 for D_3MFT scores.

4.8.1 Multivariable model for D_1MFT scores: all prisoners

The age, gender adjusted robust regression model including all the considered risk indicators explained 41% of the variance in D_1MFT scores (Adjusted $R^2 = 0.41$, $F(19, 119) = 5.83$, $p < 0.0001$, mean (max) VIF =1.44(2.19)). Prisoners with complete observations for all risk indicators were limited to $n = 139$ (see Model 1, Table 4.18).

From the stepwise analyses (restricted to complete observations), the minimal age, gender adjusted model for D_1MFT scores ($F(6, 132) = 13.84$, $p < 0.0001$, adjusted $R^2 = 0.43$) included four risk indicators: length of homelessness ($p = 0.102$), number of cigarettes smoked per day ($p = 0.122$), IDU ($p < 0.001$), and dental anxiety ($p = 0.162$). When fitted to all prisoners with complete observations ($n = 249$), age, number of cigarettes per day, IDU, and dental anxiety significantly explained D_1MFT scores (see Model 2, Table 4.18). Two risk indicators were non-significant: gender ($p = 0.102$) which was included based on *a priori* evidence, and length of homelessness ($p = 0.229$). Removing length of homelessness did not improve the model as determined from the AIC value which was 1541 for models with and without length of homelessness when restricted to the same $n = 249$ observations. Excluding both gender and length of homelessness did not improve the variance in D_1MFT scores explained (see Model 3, Table 4.18).

Thus, D_1MFT scores among all prisoners were significantly higher with increasing age ($p < 0.001$) and for every 10 year increase in age the mean scores increased by 3.4. Furthermore, for every 10 more cigarettes smoked per day the D_1MFT mean scores increased by 1 ($p = 0.001$) and mean scores were significantly higher with increasing dental anxiety ($p = 0.024$). There was strong evidence that intravenous drug use (IDU) was associated ($p = 0.001$) with significantly higher D_1MFT scores with an average increase of four.

The contribution of length of homeless, whilst non-significant ($p = 0.229$), could be due to its correlation with other risk indicators entered into the final model. For this study population, length of homelessness was associated with IDU ($r_s = 0.412$, see Appendix Table 9.7 and section 4.5.1), with 82% of prisoners reporting IDU also ever homeless compared to 31% not reporting IDU who were homeless. Both length of homelessness and IDU were also associated with higher D_1MFT scores (see Table 4.10).

4.8.2 Multivariable model for D_3MFT scores: all prisoners

The age, gender adjusted robust regression model including all risk indicators to be considered explained 52% of the variance in caries into dentine (D_3MFT) scores (Adjusted $R^2 = 0.52$, $F(19, 119) = 9.32$, $p < 0.0001$, mean (max) VIF = 1.44 (2.19)). Prisoners with complete observations for all risk indicators were again limited to $n = 139$ (see Model 1, Table 4.19)

When restricted to complete observations, the stepwise analyses, determined a minimal age, gender adjusted model ($F(12, 126) = 13.99$, $p < 0.0001$, Adjusted $R^2 = 0.53$) which included eight risk indicators: IDU, length of homelessness, drug rehabilitation, attendance at the prison dentist, common risk factor health condition, marital status, and reason for last dental attendance; sentence years was included to explain prison dentist. When the model was repeated in all prisoners complete for observations on these retained indicators ($n = 165$), gender ($p = 0.828$) and three risk indicators were non-significant: marital status ($p = 0.752$), reason for last attendance ($p = 0.225$) and the measure for health conditions sharing common risk factors ($p = 0.311$). An analysis using AIC was undertaken to determine if any of these could be removed.

Table 4.18 Results of stepwise age and gender adjusted multiple-regression of D_1MFT scores: whole study population

Risk indicator	Model 1		Model 2		Model 3	
	β* (95% CI)	***p-value***	***β* (95% CI)***	***p-value***	***β* (95% CI)***	***p-value***
Age (years)	0.27 (0.17, 0.38)	**<0.001**	0.34 (0.28, 0.41)	**<0.001**	0.33 (0.27, 0.40)	**<0.001**
Female	-2.44 (-4.79, -0.09)	**0.042**	-1.38 (-3.02, 0.27)	0.102	-	-
Length of homelessness	0.51 (-0.26, 1.28)	0.195	0.39 (-0.25, 1.04)	0.229	-	-
Number cigarettes smoked per day	0.07 (-0.03, 0.16)	0.167	0.10 (0.04, 0.16)	**0.001**	0.10 (0.04, 0.16)	**0.001**
Intravenous drug use	5.42 (2.10, 8.74)	**0.002**	3.99 (1.61, 6.37)	**0.001**	3.99 (1.68, 6.29)	**0.001**
MDAS (dental anxiety) score	0.10 (-0.05, 0.26)	0.201	0.13 (0.02, 0.25)	**0.024**	0.14 (0.02, 0.25)	**0.019**
Attended prison dentist	1.27 (-0.71, 3.25)	0.206	-	-	-	-
Time imprisoned (years)	-0.07 (-0.23, 0.10)	0.422	-	-	-	-
Reason for last dental attendance		0.289	-	-	-	-
Trouble with teeth/gums	1					
Check-up	-0.06 (-2.30, 2.19)	0.960				
'Other' reason	-2.54 (-5.78, 0.69)	0.122				
Placed in care as child/teenager	-1.13 (-3.37, 1.11)	0.320	-	-	-	-
Preferred extraction for front tooth requiring treatment	1.72 (-2.19, 5.64)	0.386	-	-	-	-
Health condition(s) with shared common risk factors	0.83 (-1.18, 2.84)	0.414	-	-	-	-
Taken part in drug rehabilitation programme	0.99 (-1.73, 3.70)	0.472	-	-	-	-
Non-stable community accommodation	1.09 (-2.03, 4.22)	0.490	-	-	-	-
Marital status		0.409	-	-	-	-
Single	1					
Married, cohabiting	-1.06 (-3.55, 1.44)	0.404				
Separated, divorced, widowed	1.68 (-2.38, 5.75)	0.414				
Attained mandatory education (16 years of age)	0.60 (-1.13, 2.34)	0.492	-	-	-	-
Any (illegal) drug use	0.32 (-2.13, 2.77)	0.797	-	-	-	-
	$F(19, 199) = 5.83$, $p < 0.0001$ Adjusted $R^2 = 0.49$ AIC = 858 *n* (%) = 139 (47)		$F(6, 242) = 29.61$, $p < 0.0001$ Adjusted $R^2 = 0.42$ AIC = 1541 *n* (%) = 249 (84)		$F(4, 248) = 41.31$, $p < 0.0001$ Adjusted $R^2 = 0.41$ AIC = 1566 *n* (%) = 253 (85)	

Model 1 = full list; Model 2 = final model including non-significant terms; Model 3 = final model excluding non-significant terms; * unstandardized *β* coefficient

The AIC improved (decreased) by 4 units when marital status was removed, and by 1 unit when reason for last dental attendance was removed. AIC did not change by removing the health conditions measure. Thus the final age, gender adjusted model ($F(8, 209) = 22.23$, $p < 0.0001$), for all $n = 218$ prisoners complete for observations, explained 47% of the variance in D_3MFT scores (see Model 2 in Table 4.19) and included six other risk indicators. length of homelessness, IDU, drug rehabilitation, prison dentist (and time imprisoned), and shared common risk factor health condition.

In the final explanatory model for D_3MFT scores only three risk indicators were significantly predictive for this study population: age ($p < 0.001$), IDU ($p = 0.001$), and length of homelessness ($p = 0.016$), where for every 10 year increase in age the mean D_3MFT scores increased by 3, and IDU and longer lengths of homelessness were associated with higher scores. Drug rehabilitation did not significantly ($p = 0.131$) explain D_3MFT scores however this indicator was associated with both IDU ($r_s = 0.488$) and length of homelessness ($r_s = 0.213$), and despite being related to these other model terms, the effect size was still reasonably moderate (unstandardized $\beta = 1.63$) indicating mean D_3MFT scores were almost 2 units higher for prisoners who had participated in a drug rehabilitation programme. The evidence for the remaining non-significant risk factors (prison dentist & time imprisoned, and health conditions) was weaker but they were retained because the model fit was better as determined by the AIC. Because dental attendance in the prison setting is prioritized based on need, it is not unexpected that prison dentist explained D_3MFT scores since this score is intrinsically a measure of severe dental caries requiring treatment; the term sentence years was included to explain prison dentist.

Table 4.19 Results of stepwise age and gender adjusted multiple-regression of D_3MFT scores: whole study population

Risk indicator	Model 1		Model 2		Model 3	
	β (95% CI)*	*p-value*	*β* (95% CI)*	*p-value*	*β* (95% CI)*	*p-value*
Age (years)	0.31 (0.21, 0.40)	**<0.001**	0.30 (0.23, 0.38)	**<0.001**	0.40 (0.34, 0.46)	**<0.001**
Female	-1.31 (-3.58, -0.96)	0.254	-0.35 (-2.12, 1.42)	0.698	-	-
Length of homelessness	0.28 (-0.48, 1.04)	0.471	0.83 (0.15, 1.50)	**0.016**	0.49 (-0.10, 1.08)	0.102
Number cigarettes smoked per day	0.05 (-0.04, 0.14)	0.253	-	-	-	-
Intravenous drug use	5.74 (2.57, 8.90)	**<0.001**	4.44 (1.89, 6.99)	**0.001**	4.63 (2.33, 6.93)	**<0.001**
MDAS (dental anxiety) score	0.05 (-0.08, 0.19)	0.440	-	-	-	-
Taken part in drug rehabilitation programme	1.50 (-1.12, 4.11)	0.260	1.63 (-0.49, 3.75,)	0.131	-	-
Attended prison dentist	1.76 (-0.12, 3.64)	0.065	0.91 (-0.65, 2.46)	0.252	-	-
Time imprisoned (years)	-0.07 (-0.24, 0.10)	0.423	0.12 (-0.05, 0.29)	0.150	-	-
Health condition(s) with shared common risk factors	1.44 (-0.45, 3.33)	0.133	0.75 (-0.74, 2.25)	0.322	-	-
Attained mandatory education (16 years of age)	0.58 (-1.09, 2.24)	0.496	-	-	-	-
Marital status		0.190	-	-	-	-
Single	1					
Married, cohabiting	-1.37 (-3.63, 0.89)	0.232				
Separated, divorced, widowed	2.01 (-1.71, 5.72)	0.287				
Non-stable community accommodation	1.31 (-1.51, 4.12)	0.360	-	-	-	-
Placed in care as child/teenager	-1.48 (-3.61, 0.66)	0.174	-	-	-	-
Any (illegal) drug use	1.05 (-1.11, 3.20)	0.338	-	-	-	-
Reason for last dental attendance		0.051	-	-	-	-
Trouble with teeth/gums	1					
Check-up	-0.57 (-2.71, 1.58)	0.603				
'Other' reason	-3.12 (-5.62, -0.62)	**0.015**				
Preferred extraction for front tooth requiring treatment	2.17 (-1.81, 6.16)	0.282	-	-	-	-
	$F(19, 199) = 9.32$, $p < 0.0001$ Adjusted $R^2 = 0.52$ AIC = 839 *n* (%) = 139 (47)		$F(8, 209) = 22.23$, $p < 0.0001$ Adjusted $R^2 = 0.47$ AIC = 1348 *n* (%) = 218 (73)		$F(3, 270) =$, $p < 0.0001$ Adjusted $R^2 = 0.48$ AIC = 1694 *n* (%) = 274 (92)	

Model 1 = full list; Model 2 = final model including non-significant terms; Model 3 = final model excluding non-significant terms; * unstandardized *β* coefficient

4.9 Models for D_1MFT and D_3MFT scores: female prisoners

4.9.1 Multivariable model for D_1MFT scores: females

For female offenders, the twelve potential risk indicators considered for age-adjusted multiple regression analyses of D_1MFT scores were: attained mandatory education, length of homelessness, number of remands, health condition(s) with common risk factors, number cigarettes smoked per day, any drug use, IDU, drug rehabilitation, reason for last dental attendance, treatment preferences for front and back teeth (Table 4.17), and dental anxiety which was indicated from the analysis of all prisoners combined (Table 4.18).

Due to limited observations (32 in total), and in consideration of the number of risk indicators to be considered, a pragmatic decision was taken to remove variables with greater than 20% missing entries for female prisoners. Accordingly, number of remands (n = 67 observations) and reason for last dental attendance (n = 69) were removed. The resulting age-adjusted model for the remaining ten risk indicators (58 observations) explained 49% of the variance in D_1MFT scores among females examined (Adjusted R^2 0.49, $F(11, 46) = 10.57$, $p < 0.0001$, mean (max) VIF = 1.54 (2.62)).

At the end of the stepwise selection, the age-adjusted model included four potential risk indicators: number cigarettes smoked per day, IDU, and the treatment preference measures for front and back teeth. When repeated in all females complete for observations (n = 65), all but one risk indicator (treatment preference back teeth) were significant at $p < 0.05$ – exact p-values are reported in Model 1, Table 4.20 (page 161). Since preferences for extraction (rather than restorative treatment) for back teeth was correlated with the model term for treatment preferences for front teeth ($r_s = 0.424$) both were retained in the final model. Thus the model at the end of the stepwise selection was considered the final model ($F(5, 59) = 26.48$, Adjusted $R^2 = 0.56$) and explained 56% of the variance in D_1MFT scores among females where for every 10 years of age the mean D_1MFT scores were estimated to increase by 3.3, for every 10 additional cigarettes smoked per day the mean scores were estimated to increase by almost 2, those reporting IDU had mean scores 4 units higher and those preferring extraction, to restorative treatment, were estimated to have D_1MFT scores 3 or 4 units higher.

4.9.2 Multivariable model for D_3MFT scores: females

For female offenders, fourteen potential risk indicators were considered for the multiple regression model of D_3MFT scores, including attained mandatory education, parenthood/resident parents, length of homelessness, time imprisoned, attendance at the prison dentist, number of remands, number of cigarettes smoked per day, any drug use, IDU, drug rehabilitation, reason for last attendance, and the two measures for dental treatment preferences, from the univariable analysis (see Table 4.11) alongside the measure for health condition(s) with shared common risk factors from the final D_3MFT model for all prisoners (see Table 4.19).

Limited observations (23 in total) once again impeded age adjusted analyses of the full set of 14 potential risk indicators. Thus, those with greater than 20% missing values were removed for a second time: number of times remanded, reason for last dental attendance, and, additionally, shared residence with children (n = 66). Therefore, 11 potential risk indicators were entered into the initial age-adjusted model (53 observations) which explained 52% of the variance in D_3MFT scores ($F(12, 40) = 14.13$, $p < 0.0001$, mean (max) VIF = 1.65 (2.65)).

The stepwise procedure determined an age-adjusted model with five potential risk indicators: age, time imprisoned, number of cigarettes smoked per day, IDU, and treatment preferences for front and back teeth ($F(6, 46) = 20.91$, $p < 0.0001$, mean (max) VIF = 1.30 (1.41). When repeated for all females complete for observations data for five additional females was incorporated; the final age-adjusted model explained 60% of the variance in D_3MFT scores ($F(6, 46) = 20.91$, $p < 0.0001$, mean (max) VIF = 1.25 (1.34)). Age, number of cigarettes smoked per day, IDU and treatment preferences for back teeth were significant at $p < 0.05$ – see Table 4.20 for exact values, where an increase in age of 10 years was again associated with an increase of 3.3 in the mean D_3MFT scores, for every 10 additional cigarettes smoked per day the mean D_3MFT scores were estimated to increase by 2, IDU was associated with mean D_3MFT scores of 5 units higher and preferences for extraction, rather than restorative treatment, for back teeth was associated with mean scores 3.5 units higher. As already described, whilst treatment preferences for front teeth were not significant in the final model (p = 0.092) the two parameters for treatment preference are correlated. Time imprisoned, which was also non-significant (p = 0.143), was moderately correlated with age ($r_s = 0.299$, p = 0.009) among female prisoners.

Table 4.20 Results of stepwise age adjusted multiple-regression of D_1MFT and D_3MFT scores: female prisoners

Risk indicator	Model 1 (total obvious decay): D_1MFT scores		Model 2 (caries into dentine): D_3MFT scores	
	Unstandardized β (95% CI)	*p-value*	Unstandardized β (95% CI)	*p-value*
Age (years)	0.33 (0.22, 0.44)	**<0.001**	0.33 (0.22, 0.45)	**<0.001**
Number cigarettes smoked per day	0.20 (0.08, 0.32)	**0.002**	0.22 (0.07, 0.37)	**0.006**
Intravenous drug use	4.39 (0.53, 8.24)	**0.027**	5.41 (1.23, 9.60)	**0.012**
Prefer extraction for front tooth needs crowned	4.20 (0.52, 7.89)	**0.026**	3.47 (-0.58, 7.52)	0.092
Prefer extraction for back tooth requires filling	2.73 (-0.21, 5.68)	0.068	3.46 (0.17, 6.74)	**0.040**
Time imprisoned	-	-	0.25 (-0.09, 0.60)	0.143
	$F(5, 59) = 26.48$, Adjusted $R^2 = 0.56$		$F(6, 50) = 22.13$, Adjusted $R^2 = 0.60$	

4.10 Models for D_1MFT and D_3MFT: long-stay adult male prisoners

4.10.1 Multivariable model for D_1MFT scores: long-stay adult males

Alongside age, fourteen potential risk indicators were considered for D_1MFT scores among adult males: shared residence with children, non-stable accommodation just prior to prison, length of homelessness, placed in care, time imprisoned, health condition(s) with common risk factors, number cigarettes smoked per day, any illegal drug use, IDU, drug rehabilitation, prison dental attendance, attendance for preventive dental treatment, and avoid sugars between meals at home, from the univariable analysis (see Table 4.10) and dental anxiety from the final D_1MFT model for all prisoners (see Table 4.18).

The age-adjusted model including all potential risk indicators explained 32% of the variance in D_1MFT scores ($F(16, 30) = 5.10$, $p = 0.0001$, mean (max) VIF = 2.22 (3.52)) based on 47 observations. To minimize overfitting, attendance for preventive treatment ($n = 81$ observations) was removed from analyses due to >20% missing values and the stepwise procedure was completed with age alongside thirteen potential risk indicators and 61 observations in total.

The stepwise procedure determined a minimal age adjusted model with seven potential risk indicators: length of homelessness, avoidance of sugars between meals at home, IDU, attendance at prison dentist, non-stable accommodation just prior to prison, shared residence with children, and time imprisoned ($F(9, 51) = 7.67$, $p < 0.0001$, Adjusted $R^2 = 0.46$). When including all adult males with complete observations ($n = 79$), none of these potential risk indicators were significant at $p < 0.2$, however removing shared residence with children, which had the highest p-value ($p = 0.576$), improved the AIC (from 498 to 495), and the remaining model ($F(7, 71) = 14.51$, $p < 0.0001$, Adjusted $R^2 = 0.45$) fulfilled the criteria for all parameters to have $p < 0.2$ – the only exception was time imprisoned ($p = 0.434$) which was included to explain attendance at prison dentist ($p = 0.195$).

An age adjusted model with the remaining six potential risk indicators, when fitted to adult males complete for observations ($n = 97$), explained 45% of the variance in D_1MFT scores ($F(7, 89) = 15.00$, $p < 0.0001$, Adjusted $R^2 = 0.45$, mean (max) VIF = 1.25 (1.41)), see Model 1, Table 4.21. In this final model, increasing age ($p < 0.001$), non-stable community accommodation ($p = 0.036$), and IDU ($p = 0.039$) significantly explained higher D_1MFT scores. A 10 year increase in age was associated with 3.4 increase in D_1MFT scores, those living in a non-stable accommodation just prior to prison had an average score four units higher, and IDU associated with scores 3 units higher. There was some evidence ($p = 0.054$) that those avoiding sugars between meals at home had lower mean D_1MFT scores, and limited evidence that longer lengths of homelessness ($p = 0.156$) and attendance at the prison dentist ($p = 0.162$) were associated with higher D_1MFT scores.

In the adult male population length of homelessness was correlated with IDU ($r_s = 0.457$, $p < 0.001$), and non-stable community accommodation ($r_s = 0.340$, $p < 0.001$). Thus the shared variance between these measures may adversely influence the estimated effects of length of homelessness in the final model.

4.10.2 Multivariable model for D_3MFT scores: long-stay adult males

Fifteen potential risk indicators were considered for age adjusted multiple regression analysis of D_3MFT scores among adult males: these were identical to those considered for D_1MFT among this population with the addition of toothbrushing with fluoride toothpaste in the home setting.

An age adjusted model including all potential indicators ($F(16, 25) = 8.68$, Adjusted $R^2 = 0.51$, mean (max) VIF = 2.15 (3.29)) was limited to $n = 48$ observations. Again a pragmatic decision was taken to remove attendance for preventive treatment to allow for sufficient observations. The stepwise analyses was thus calculated with data from 63 adult males and the initial model explained 50% of the variance in D_3MFT scores ($F(15, 47) = 5.08$, Adjusted $R^2 = 0.50$, mean (max) VIF = 1.92 (2.89)).

At the end of the stepwise multiple regression models the minimal age adjusted model for D_3MFT scores among adult males included seven potential risk indicators: non-stable community accommodation, length of homelessness, prison dental attendance and the accompanying time imprisoned measure, health condition(s) with shared common risk factors, IDU, and behaviour of toothbrushing in the home setting ($F(8, 54) = 9.32$, Adjusted $R^2 = 0.52$, mean (max) VIF = 1.41 (1.64)). When repeated in the adult male population complete for observations ($n = 85$), these risk indicators explained 53%

of the variance in D_3MFT scores ($F(8, 76) = 12.78$, Adjusted $R^2 = 0.53$, mean (max) VIF = 1.36 (1.68)).

In contrast with the model for D_1MFT scores, non-stable community accommodation and attendance at the prison dentist was more significantly and more strongly (as evidenced by the larger β coefficients) associated with D_3MFT scores; those living in a non-stable accommodation had mean D_3MFT scores 5 units higher and those attending the prison dentist had D_3MFT scores on average 2 units higher. Other significant risk factors for D_3MFT were age ($p < 0.001$), and IDU ($p = 0.009$); whereas tootbrushing in the home setting was significantly ($p = 0.017$) protective. A 10 year increase in age was associated with 2.8 increase in D_3MFT scores, and IDU was again associated with scores on average 3 units higher; toothbrushing with fluoride toothpaste in the home setting was associated with D_3MFT scores on average 3 units lower. The evidence that increasing length of homelessness was associated with higher scores was stronger for D_3MFT although still non-significant ($p = 0.089$). There was some limited evidence ($p = 0.194$) that adult males with a health condition which shared common risk factors to dental caries had higher D_3MFT scores.

When interpreting the non-significant findings for length of homelessness and health conditions, it should be noted the effect sizes may have been adversely influenced by intra-correlations (shared variance) between the model terms. In the adult male population, length of homelessness was correlated with three risk factors: non-stable community accommodation ($r_s = 0.340$, $p < 0.001$), IDU ($r_s = 0.457$, $p < 0.001$) and common risk factor health conditions ($r_s = 0.301$, $p = 0.003$). Furthermore, common risk factor health conditions were also correlated with IDU ($r_s = 0.278$, $p = 0.008$) as well as with age ($r_s = 0.385$, $p < 0.001$).

Table 4.21 Results of stepwise age adjusted multiple-regression of D_1MFT and D_3MFT scores: long-stay adult males

Risk indicator	**Model 1 (total obvious decay): D_1MFT scores**		**Model 2 (caries into dentine): D_3MFT scores**	
	Unstandardized β (95% CI)	*p-value*	Unstandardized β (95% CI)	*p-value*
Age (years)	0.34 (0.23, 0.45)	**<0.001**	0.28 (0.17, 0.40)	**<0.001**
Non-stable accommodation	4.56 (0.32, 8.81)	**0.036**	5.49 (1.42, 9.57)	**0.009**
Intravenous drug use	3.48 (0.19, 6.77)	**0.039**	3.30 (0.25, 6.36)	**0.034**
Avoided sugars between meals in home setting	-2.32 (-4.67, 0.04)	0.054	-	-
Length of homelessness	0.96 (-0.37, 2.29)	0.156	1.01 (-0.16, 2.17)	0.089
Attendance at prison dentist	1.81 (-0.74, 4.35)	0.162	2.48 (0.05, 4.90)	**0.045**
Time imprisoned	-0.09 (-0.30, 0.12)	0.407	-0.13 (-0.34, 0.08)	0.233
Used toothbrush and fluoride toothpaste in home setting	-	-	-2.63 (-0.49, -4.78)	**0.017**
Health condition with shared common risk factors	-	-	1.51 (-0.77, 3.80)	0.194
	$F(7, 89) = 15.00$, Adjusted $R^2 = 0.45$		$F(8, 76) = 12.78$, Adjusted $R^2 = 0.53$	

4.11 Models for D_1MFT and D_3MFT scores: male young offenders

It was not possible to calculate reliable multivariable models to explain variances in either total obvious decay (D_1MFT), or caries into dentine (D_3MFT), scores in male young offenders (Adjusted $R^2 < 0.1$). Limited observations were not the cause of these findings; the specific steps to resolve each outcome score are outlined below.

4.11.1 Multivariable model for D_1MFT scores: male young offenders

For D_1MFT scores among male young offenders, three potential risk indicators were identified from the univariable analysis: attendance at the prison dentist, time imprisoned, and the MDAS (dental anxiety) score; and an additional two potential risk indicators were to be included from the results from the multivariable regression for D_1MFT among all prisoners: length of homelessness, and number cigarettes smoked per day. Together these five potential indicators did not significantly explain the variance in D_1MFT scores among male young offenders ($F(6, 78) = 2.15$, $p = 0.0573$, Adjusted $R^2 = 0.08$), with $n = 85$ observations in total.

Following the standard stepwise method, as previously used, length of homelessness ($p = 0.295$) was removed. The resulting model with age ($p = 0.948$), prison dental attendance ($p = 0.021$), time imprisoned ($p = 0.454$), MDAS score ($p = 0.023$) and number cigarettes smoked per day ($p = 0.190$) was borderline significant ($F(5, 79) = 2.35$, $p = 0.0484$, mean (max) VIF = 1.13 (1.22)), however only explained 7% of the variance in D_1MFT scores.

The latter model was fitted to all male young offenders complete for observations ($n = 88$) and the stepwise regression method repeated; this time number of cigarettes was removed ($p = 0.334$) and in the resulting model ($F(4, 83) = 2.66$, $p = 0.0381$) two potential risk indicators were non-significant: age ($p = 0.991$), and time imprisoned ($p = 0.675$) where the latter was included to explain prison dentist. Following our stated aim to develop a minimal *age* adjusted model the resulting model would have been considered final (see Model 1, Table 4.22), however when fitted to all male young offenders complete for observations ($n = 90$) Model 1 still explained only 7% of variance in D_1MFT scores ($F(4, 85) = 2.56$, $p = 0.0442$, Adjusted $R^2 = 0.07$, mean (max) VIF = 1.10 (1.18)). Since age was not significantly associated with D_1MFT

scores (p = 0.958), and the age range for this population was narrow, a decision was taken to remove age.

In the final unadjusted model for D_1MFT scores (F(3, 86) = 3.45, p = 0.0200, Adjusted R^2 = 0.08, mean (max) VIF = 1.08 (1.12)) attendance at the prison dentist and MDAS significantly explained higher D_1MFT scores (see Model 2, Table 4.22). Time imprisoned was not significantly associated with D_1MFT scores (p = 0.679) however was retained to ensure findings for attendance at prison dentist were interpretable. The increase in percentage variance explained was however trivial (from 7% to 8%).

4.11.2 Multivariable model for D_3MFT scores: male young offenders

Only two potential risk indicators for D_3MFT scores were determined from the univariable analysis among male young offenders: marital status and MDAS score. Following the stated methods another six were to be considered from the final D_3MFT model for all prisoners: length of homelessness, IDU, drug rehabilitation, attendance at the prison dentist, time imprisoned, and health conditions with shared common risk factors (Table 4.19).

An age adjusted model with all of the above terms entered did not significantly explain D_3MFT scores among male young offenders (F(8, 60) = 1.15, p = 0.3427, Adjusted R^2 = 0.02), despite sufficient observations (n = 69). A pragmatic decision was taken to first compare this model to a second age adjusted model restricted to potential risk indicators identified from the univariable analysis of male young offenders alone. However, the age adjusted model including only marital status and MDAS scores also did not significantly explain the variance in D_3MFT scores for this population (F(3, 65) = 1.57, p = 0.2050, Adjusted R^2 = 0.03, mean (max) VIF = 1.03 (1.04)). Since there were no associations between these remaining potential risk indicators and each one had a p-value > 0.1 (see Model 3, Table 4.22), it was not possible to perform a multivariable analyses to explain D_3MFT scores. When considered independently, age alone did not significantly explain D_3MFT scores (F(1, 97) = 0.56, p = 0.4566), nor did marital status alone (F(2, 92) = 0.73, p = 0.4855). MDAS scores did significantly explain higher D_3MFT scores (F(1, 96) = 6.04, p = 0.0158, Adjusted R^2 = 0.05) however less than 90% of the variance was explained.

Table 4.22 Results of stepwise age adjusted multiple-regression of D_1MFT and D_3MFT scores: male young offenders

Risk indicator	Model (total obvious decay): D_1MFT scores				Model (caries into dentine): D_3MFT scores	
	Unstandardized *β* (95% CI)	*p-value*	Unstandardized *β* (95% CI)	*p-value*	Unstandardized *β* (95% CI)	*p-value*
	Model 1		**Model 2**		**Model 3**	
Age (years)	0.03 (-1.11, 1.17)	0.958	-	-	0.35 (-0.84, 1.55)	0.558
Attendance at prison dentist	2.40 (0.04, 4.76)	**0.047**	2.41 (0.13, 4.69)	**0.038**	-	-
Time imprisoned	-0.13 (-0.77, 0.51)	0.679	-0.13 (-0.76, 0.50)	0.679	-	-
MDAS (dental anxiety) score	0.22 (0.03, 0.41)	**0.024**	0.22 (0.03, 0.41)	**0.023**	0.18 (-0.04, 0.40)	0.111
Marital status	-	-	-	-	-3.09 (-6.89, 0.72)	0.110
	$F(4, 85) = 2.56$, Adjusted $R^2 = 0.07$ AIC = 539		$F(3, 86) = 3.45$, Adjusted $R^2 = 0.08$ AIC = 537		$F(3, 65) = 1.57$, Adjusted $R^2 = 0.03$ AIC = 403	

Summary of final multivariable models for caries scores

All prisons combined (age and gender adjusted):

- For D_1MFT, three risk indicators significantly explained higher scores: number of cigarettes smoked per day, intravenous drug use (IDU), and the Modified Dental Anxiety Score (MDAS). Length of homelessness, whilst non-significant, also improved model fit. Together these explained 42% of the variance in D_1MFT scores.
- Similarly, for D_3MFT, increasing length of homelessness and IDU were significant risk indicators for higher scores. The following, although non-significant, also improved model fit: participation in drug rehabilitation programme, attendance at prison dentist (with confounding for time imprisoned), and having a health condition with shared common risk factors. Together these explained 47% of the variance in D_3MFT scores.

Females (age adjusted):

- For D_1MFT, number of cigarettes smoked and IDU were again significant risk indicators for higher scores. Dental treatment preferences explained D_1MFT scores since preferences for extraction, rather than treatment, for a front tooth significantly explained higher scores and the equivalent findings for back teeth also improved model fit. Together these explained 56% of the variance in D_1MFT scores.
- The model for D_3MFT scores was broadly similar to that for D_1MFT among females, although additionally included time imprisoned (independently of prison dental attendance). The final model explained 60% of the variance in D_3MFT scores.

Long-stay adult males (age adjusted):

- For D_1MFT, IDU was again retained as a significant risk indicator for higher scores. Living circumstances and dental-related behaviours were also important since: a non-stable accommodation just prior to prison significantly explained higher scores; longer periods of homelessness and an attendance at the prison dentist (with confounding for time imprisoned) also explained higher scores whereas avoiding sugars between meals in the home setting explained lower scores. Together these explained 45% of the variance in D_1MFT scores.
- For D_3MFT, in place of sugar consumption behaviours, toothbrushing with fluoride toothpaste in the home setting was significantly protective. Additionally, having a health condition with shared common risk factors also improved model fit and, whilst non-significant, was associated with higher scores. Together these explained 53% of the variance in D_3MFT scores.

Male young offenders:

- It was not possible to reliably calculate models to explain variances in either D_1MFT or D_3MFT scores for this population.
- The best models computed explained less than 10% of the variance in D_1MFT scores and less than 5% of the variance in D_3MFT scores.
- The most informative risk indicator for this population, from this study, appeared to be MDAS which significantly explained D_1MFT scores.

5 Discussion

5.1 Introduction

This study analysed data from the Scottish Oral Health Improvement Prison Programme (SOHIPP) survey which captured detailed dental caries experience (prevalence and severity) for almost three hundred Scottish prisoners representative of females, long-stay adult males and male young offenders. A range of potential risk indicators were included for measurement, some of which have been reported for prisoner populations and others indicated for other populations but untested for prisoners. Two outcome measures were assessed, both of which pertained to 28 teeth (excluding third molars): total obvious decay experience (D_1MFT) and caries into dentine (D_3MFT) scores. The specific aims were:

- To document prevalence of dental caries, at D_1MFT and D_3MFT, in the prison population of Scotland using data from a cross-sectional survey, conducted in 2011, which specifically included women, youth offenders, and long stay adult male prisoners;
- To document the prevalence of known risk indicators for dental caries, at D_1MFT and D_3MFT, and test for associations with dental caries, cross-sectionally in the population of study;
- Explore the prevalence of other hypothesised risk indicators for dental caries, at D_1MFT and D_3MFT, and specifically test their association with dental caries in the population of study;
- Build the 'best' explanatory model, or models if data support different risk indicator experiences in the sub-populations studied, for dental caries at D_1MFT and D_3MFT.

To address these aims, results from age (and gender) adjusted robust linear regression analyses (referred to as 'univariable' in this thesis) were used to screen for potential risk or preventive indicators (hereafter collectively shortened to 'indicators'). Multivariable robust regressions (all age (gender) adjusted) were subsequently undertaken to determine which indicators collectively best explained the variance in D_1MFT and D_3MFT outcome scores.

In preparation for the multivariable analyses, the methods included remedial measures to identify and remove highly correlated potential indicators thus minimising multicollinearity which could result in less precise final models. Despite these steps, the sample numbers were not sufficiently large enough to permit full investigations of the best explanatory potential indicators for the individual populations and the reasons were not attributable to data missingness but rather the cumulative effect of different missing observations across the potential indicators. Thus a small number of indicators were omitted: reason for last dental attendance, number of remands and shared residence with children, whilst significant in the univariable analyses, were not explored further in multivariable models for female prisoners and the multivariable analyses for adult males excluded attendance for preventive treatment.

Despite the data limitations, when the results of both univariable and multivariable analyses are considered in unison, it is evident, whilst the indicators generally showed the same pattern or direction of association in each of the prison-specific models, the three Scottish populations of females, long-stay adult males, and male young offenders do not have identical experiences for significant measures which explain D_1MFT and D_3MFT scores. In the final models, only one statistically significant risk indicator, intravenous drug use (IDU), was a common explanatory indicator between adult males and females. No other published study has empirically assessed the association between this number of potential indicators and caries outcomes in prisoners with a specific aim to identify differences for sub-populations of interest. The emerging findings within the context of the wider literature will be discussed in detail below.

5.2 Sample representativeness

When compared to the national Scottish prisons population in the same year [139] the study population has higher proportions of males aged 20-24 years of age (peaks at 25-29 years for national statistics); a similar trend was observed for women although the difference less pronounced. These differences may be explained by the recruitment strategy since only three prison sites were sampled and a third of the population was oversampled young male participants (held at HMYOI Polmont). Additionally, the study visits were restricted to certain residential halls which may have influenced the age demographics available for recruitment. Other socio-demographic measures showed reasonable agreement with published figures for the national prisons population.

Most respondents (93%) were of 'White' ethnicity which is consistent with the observed figures for all Scottish prisons [164]. In the absence of data for the national Scottish prisons population, the employment data were compared with a study of prisoners in England and Wales [165] and, whilst not directly comparable (due to differences in employment classifications), the percentages are similar – 26% in paid employment compared with 32% of prisoners in England and Wales. The findings for having children were also similar to a Scottish Prison Service (SPS) survey in the same year (50% compared to 48% in SPS survey) as was the proportion of people in care (33% compared with 28% respectively) [166]. Therefore, it may be suggested that this sample of people in Scottish prisons reflected the demographics of prisoners elsewhere in the United Kingdom.

5.3 Dental caries experience

One of the key aims for this thesis was to document prevalence of dental caries in the prison population of Scotland and to review differences between women, youth offenders, and long-stay adult male prisoners. Ninety-seven percent of the study population were assessed with total obvious decay experience (D_1MFT) and similar proportions (96%) had caries into dentine (D_3MFT). Whilst there was some variability between the prison populations the prevalence of dental caries experience was notably high, and even among male young offenders 94% had obvious decay experience, and 92% had caries into dentine. The high prevalence of caries among all three populations and the extent to which decayed contributed to the total D_1MFT and D_3MFT scores highlighted the continuing unmet dental treatment need among the Scottish prisons population. The resulting impact in terms of oral health related quality of life was evident when compared to the Adult Dental Health Survey (ADHS) of the UK general population in 1998, with higher proportions of prisoners affected across dimensions encompassing physical, psychological and social disabilities [70].

The last ADHS to include Scottish adults was performed in 1998 [110], therefore, in the absence of contemporary data, comparisons between the prisoners studied in SOHIPP and general population data for Scotland were not possible. The results were compared to the 2009 ADHS (Scotland did not participate), and whilst not directly comparable due to differences in methodologies. For example, the ADHS criteria excluded caries deemed to be in an "arrested" state whereas the SOHIPP protocol did not incorporate caries activity thus all disease states were recorded, it was nevertheless possible to explore apparent differences. Table 5.1 shows comparable data for SOHIPP dentate prisoners and 2009 non-prisons population in England [167] or England, Wales, and Northern Ireland combined [168].

The percentage of edentate prisoners was broadly similar to the general population (5% vs 6%) [169]. Greater proportions of Scottish prisoners had at least one decayed tooth when compared with the general population, although the average number of teeth affected was broadly similar between the prisons and non-prisons populations. Lower proportions of Scottish prisoners had received restorative dental treatment when compared with the 2009 ADHS; Scottish prisoners had on average 3.65 restored teeth compared with a mean of 6.7 restored teeth of the 2009 ADHS population. Combined these features suggest that prisoners experience greater caries experience, however receive less dental treatment when compared with the 2009 ADHS population surveyed.

Table 5.1 Comparison of dental caries experience between prisoners and general non-prisons population in England

	SOHIPP 2011*	ADHS 2009
Percentage of dentate adults with caries	67.8%	31%
Mean number teeth with caries	2.84 (*SD* 3.21)	2.7
Percentage of dental adults with a restoration	76.3%	85%
Average number of restored teeth	3.65 (*SD* 3.63)	6.7

* Data for D_1MFT, 32 teeth, n = 283 dentate participants

To further understand how caries experience may have changed over time within the Scottish prisons population, the findings were compared to the last prisons dental survey, conducted almost 10 years before [66]. Due to methodological differences comparisons were feasible for D_1MFT and severe decay extending to dental pulp (D_4T) and only for female prisoners and male young offenders; the 2002 survey also included HMP Shotts although the caries data reported does not permit direct comparisons. Whilst the 2011 SOHIPP sample is slightly older it is likely this reflects the background trend of the Scottish prisons population increasing in age, [66] rather than methodological differences; nevertheless the age difference is duly noted as a consideration for any direct comparisons.

Between 2002 and 2011, D_4T experience among male young offenders was unchanged however there was a slight increase in the mean number of teeth with D_1MFT (see Table 5.2). The latter finding can potentially be attributed to the use of more sensitive assessment criteria in SOHIPP. For females, the data overall indicate that, despite the last survey highlighting that female prisoners had fourteen times D_4T experience when compared to the national female Scottish population [66], caries experience has only moderately improved.

Table 5.2 Dental caries among Scottish prisoners between 2002 and 2011

	Females		Male young offenders		Adult males*
	2011	2002	2011	2002	2011
Sample size	90	110	99	149	109
Edentate	6	4	0	0	9
Mean age (range)**	30.2 (17-67)	27.5 (16-58)	19.7 (18-21)	18.8 (15-21)	34.7 (21-64)
Mean number teeth with total caries (D_1T)**	2.4 (*SD* 2.9)	3.8	4.3 (*SD* 3.6)	2.9	1.9 (*SD* 2.6)
Mean filled teeth (FT)**	4.2 (*SD* 4.0)	3.9	2.0 (*SD* 2.8)	2.7	4.9 (*SD* 3.5)
Percentage with decayed teeth ($D_1T > 0$)**	61	73	83	75	59
Percentage with severe decay ($D_4T > 0$),*****	35	42	31	32	74

*No data reported for 2002 [66]; **Data for 2011: exclude edentate and refer to 32 teeth without correction for standing teeth; ***Data for D_4T represents ICDAS caries codes 5 or 6.

5.4 Socio-demographics

As to be expected, the age of participants explained a large amount of the variation in both outcome scores in females and adult males, with older prisoners observed to have significantly higher D_1MFT and D_3MFT scores. The observed association among male young offenders was of the same order of magnitude (as determined from the regression coefficient) but not statistically significant; this latter finding may be explained by the narrow age range available for study among male young offenders.

Whilst three previous studies [81, 87, 89], found significant differences in dental caries outcomes by gender, this study found the variation of D_1MFT or D_3MFT did not significantly differ between adult males and adult females. The cited literature pertains to different countries and the SOHIPP population is also notably different in other key aspects, for example the most recent published study in 2006 found males were more likely to report smoking than females [89], whereas in this study the proportion of smokers did not significantly differ by prison, and high proportions across the three Scottish prisons smoked cigarettes (see Figure 4.4, p100). Another approach to examining gender inequalities in dental health experience is to consider differences when compared to gender-matched national population data. On the assumption the general population experience of D_4T remained the same since 1998 [66], the percentage of female prisoners with decayed teeth at D_4T was 11 times higher in 2011 and male prisoners (combined %D4T > 0 = 33) had three times the decayed teeth at D_4T when compared to 1998 general male population data [66].

This is the first study to show homelessness and length of homelessness is associated with dental caries (D_1MFT and D_3MFT) for females and long-stay adult male in a population of prisoners. When controlling for the effects of other potential indicators homelessness was retained as a significant explanatory parameter for both D_1MFT and D_3MFT scores for adult males. The complex relationship between homelessness and poor oral health has been documented by others [170], and this survey provides further evidence for the risk indicators which are concomitant with homelessness experience and yet complex and dissimilar between populations [132].

In the present analyses, higher D_1MFT and D_3MFT scores among adult males were significantly explained by having lived in non-stable community accommodations just prior to prison and higher scores were also associated with having been being placed in care as a child or teenager. Both these risk indicators were also related to homelessness as was IDU and drug rehabilitation which were also associated with higher D_1MFT and D_3MFT scores. Moreover, the wider impact of homelessness was highlighted by its relationship with other health conditions with shared common risk factors to caries, and an indication of medicinal-related dry mouth. These features and the need for concerted action to address the complex risk factors were highlighted by McDonagh *et al.* as was the opportunity presented to authorities including the criminal justice service to identify and target the most vulnerable populations including adult males [132].

For female offenders, the relationship between homelessness and other measures of living circumstances, as indicated above, were still valid, however different socio-demographic measures were independently related to caries: attained mandatory education and re-offending (number of remands or sentences). Both socio-demographic measures were also related with homelessness, with females experiencing longer periods of homeless having higher rates of re-offending and less likely to have stayed in education for the mandated 16 years of age in Scotland. The complex role between education alongside other factors has been documented in the context of reducing re-offending [171] as has the link between low education and health outcomes [172]. Conversely, there is also a body of evidence which highlights the link between poor dental health and childhood impacts including school attendance and school performance [173].

Beyond school age, the impact of poorer education in the pathway toward health and social impacts is frequently conceptualized as an outcome of limited literacy, although there is inconclusive research evidence to support this model [174, 175]. Nevertheless, it is universally agreed the current health literacy levels among prisoners is unacceptably poor and that public service organizations should be regularly incorporating educational programmes in the road to rehabilitation with poor literacy skills a key consideration for health intervention designs [176-178]. In Scotland, health literacy was integral to the design of health promotion materials for a programme implemented in the prison where adult males were recruited from [179]. The independent evaluation for this latter programme recognized the value of tailored educational materials but also the limitations in terms of detracting from the original intended aim to address the whole prison environment. Despite the limitations, oral health literacy was a social determinant perceived by prisoners, staff, and prison management [179].

Separate from homelessness, this study found some evidence ($p = 0.09$) that female prisoners living apart from their children had higher D_1MFT scores. Of note, there was also a relationship with age, and mothers separated from their children tended to be younger. The deleterious impact on mother *and* child resulting from parent-child separation (in the context of imprisonment) has received much attention with impacts wide-ranging e.g. physical health, mental health, social, and attitudes and behaviours although the maternal impacts have predominantly focused on mental health [180, 181].

In Scotland, over recent years the policy to address female offending has shifted toward potential for rehabilitation in the community or in purpose led community-based custodial units which would allow female offenders to be closer to their families.

This study found little evidence that time imprisoned is a risk indicator for D_1MFT or D_3MFT, however a cross-sectional study design was adopted and the influence of the prison environment in causing, worsening, or indeed preventing caries, requires longitudinal data: to date, no study has attempted to comprehensively monitor dental caries over time among a prisons population. Furthermore, the high prevalence of caries, even among the youngest participants studied, indicates substantial and complex biopsychosocial community acquired risk factors to be considered. From the literature review (see section 2.5) it is apparent prisoners needs are influenced by the prison setting, and for as yet not completely understood reasons, they are motivated and recognize opportunity to participate in maintaining dental health – although the evidence would seem to indicate the resultant goals/strategy for many are prioritised toward accessing prison dental services [182]. Whilst rehabilitation and limited access to drugs and alcohol whilst inside prison are important factors, the wider prison culture is perhaps more consequential.

The prison regime enforces routines within which autonomous action is restricted [182] and social isolation [183] is accompanied by limited access to education or work [184]. The interactions which do occur are frequently stress-inducing for prisoners and staff alike and have not engendered a trusting society [70, 183, 185]. Prison culture, prison policies and financial constraints have reportedly influenced food choices [186], and access to oral hygiene resources [70]. Limited staffing coupled with overcrowding have influenced access to healthcare and the quality of care that is provided [184]. There is of little doubt that prisoners will face a range of barriers and stressors during their stay in prison [70, 184, 185, 187] and many have been sustained over time in the UK despite numerous policy initiatives [58, 59, 188, 189]. Thus the prison environment, to some extent, engenders a culture where individual choice is limited and unhealthy decisions are easier e.g. food choices [48].

This work highlights the causes (e.g. experience of being in care as a child and teenager) of the causes (e.g. injecting drug use) and therefore it may be suggested that, in addition to health promotion interventions, there is a need for fiscal policy to redistribute the social and economic determinants of health inequality. Many of the social determinants of health described above have, thus, been recommended for policy action in a UK independent review of evidence-based public health responses to reduce health inequalities [51]. Marmot documented a six-point strategy including support for parents to secure 'the best start in life' for every child, creation of social support and opportunities including employment and healthy living environments which would enable young people the capacity and resources to take decisions about their futures.

5.5 Health conditions and medicinal-related xerostomia indicated

Health conditions known to share common risk factors (CRF) with dental caries were prevalent among all three populations although such conditions were only significantly associated with higher D_1MFT and D_3MFT scores among adult males where this measure also contributed (albeit non-significantly) to an explanatory model for D_3MFT scores. There was some limited evidence ($p = 0.07$) for an independent relationship between CRF health conditions and higher D_1MFT scores for female prisoners. The CRF model is based on a fundamental principle that health determinants are not regulated at the individual level but rather inextricably linked to 'socio-political' factors [47]. Consequentially, the individual and lifestyle measures traditionally associated with disease are markers (or 'indicators') of underlying social or environmental differences rather than the true risk factors and ultimately the impact in terms of disease experience will be co-morbidities rather than a single condition [47, 48]. In adopting this CRF approach, dental caries is cautiously linked to obesity, diabetes, cancers, and heart disease by diet. The study measures limit what conclusions can be made regarding CRF indicators, for example alcohol was not measured and nutrition was not comprehensively assessed; nevertheless a number of indicators were associated with both caries experience and CRF health conditions. Notably some were modified by the prison environment thus supporting the theory that risk indicators for caries experience are variable between prison and community settings [123].

Among females, having a CRF health condition was correlated with measures indicative of problematic drug use (IDU, drug rehabilitation) which, in turn, were also associated with higher D_1MFT and D_3MFT scores. For adult males, IDU again had a significant and detrimental association with CRF health conditions and D_1MFT and D_3MFT scores. The CRF paradigm for adult males also pointed to other concomitant risk indicators; higher proportions of adult males who were homeless, homeless for longer, or had higher depression scores also had a CRF health condition. Brushing with fluoride toothpaste in the home setting or attending for a preventive dental treatment were identified as protective indicators with regards to having significantly lower D_3MFT scores and less chance of having a CRF health condition; there was some evidence of a similar protective effect with D_1MFT scores.

The role of saliva as the human body's own defence against the pathogens which cause dental caries has been extensively documented;[190] the specific mechanisms are outwith the scope of this thesis however, in brief, are not unilateral. For example, saliva bathes the oral cavity in a solution which aids clearance of food debris thus minimizing sugars available to resident bacteria; contains electrolytes and proteins, recent investigations have identified glycoproteins which have a role in suspending bacteria, thus preventing bacterial colonization on dentition,[191] and there are more long-established theories about how the electrolytes (mainly calcium and phosphate ions) can support remineralization [190]. Changes in the salivary flow rate and composition are implicated for a number of reasons including ill health, radiation (e.g. cancer treatment), and smoking [190]. Medicinal-related dry mouth is reportedly one of the most common reasons for dry mouth experience and exacerbated by the cumulative effect of polypharmacy (i.e. multiple medicines) [192].

Among this study population the frequently prescribed medicines (analgesics, anti-depressants and methadone [70]) all had dry mouth indicated as a possible side effect [124]. Other studies have reported frequent use of xerostomia-inducing anticholinergic medications among prisoners to treat anxiety and depression or presentations with poor sleep quality with higher proportions of incarcerated women affected when compared with males [131]. The implication of these commonplace conditions and the prescribing options is relatively high numbers of prisoners receiving medicines which are vital in their road to recovery and rehabilitation [193] and yet have side effects inclusive of dry mouth which could increase risk of caries [124].

Methadone, in its sugared liquid form, is also a highly viscous preparation which, as established from the Vipeholm study in Sweden, increases risks of caries when taken between meals owing to its 'sticky' consistency [13]. Prolonged exposure is compounded by the ('relatively rare') practice of 'holding back' methadone for the purposes of illicit trading [193]. Whilst there are currently no high quality studies confirming a link between sugared methadone and dental caries[60] there are equally no studies or reports identifying whether those prescribing or dispensing in the prison setting provide attendant advice to their patients and furthermore, a Cochrane review in 2011 found "no strong evidence" for a topical intervention that effectively relieved dry mouth symptoms [194]. In Scotland, the SPS has introduced procedures for oral rinsing and checks to increase compliance [193], and a number of health assessments have highlighted the need to promote use of sugar-free methadone [66, 195].

From the present study, an indication of medicinal-related dry mouth was significantly associated with higher D_1MFT and D_3MFT scores, after adjustment for age and gender, but only in the univariable analysis for the female population. The limitations of the study design should be considered (no direct measure of salivary flow rate was made) and it is prudent to consider gender differences in health care utilization and the body of evidence that female prisoners will report ill health more often [134], and attend for higher numbers of healthcare consultations [196, 197]. In this study higher elective use of healthcare was not measured however higher proportions females were taking prescribed medicines (see Figure 4.3, page 98).

5.6 Health risk behaviours

The study did not include a measure of alcohol (mis)use which is a particular limitation for this population where problematic alcohol intake has been indicated in crime rates, emergency health care use and impacts for family relations [198]. Respondents were asked about substance use and cigarette smoking. Where problematic drug use was concerned, two specific and clearly defined measures were measured: IDU and drug rehabilitation. The estimates of effect for IDU and rehabilitation were not reliable for the male young offender population since few (< 10%) reported these characteristics (see Figure 4.4) thus making them less relevant for this population and harder to detect a difference in dental scores by presence/absence of these characteristics; the comparatively low prevalence of harmful drug misuse has been documented for other young prisoner populations [199]. The self-report data from this survey highlights the high prevalence of drug use and smoking among all three prisoner populations, so much so that the multivariable models should be interpreted with caution since disentangling any independent effects between these two behaviours is difficult.

All four health risk behaviours were independently associated with significantly higher caries experience (both D_1MFT and D_3MFT) among females and adult males. IDU was a significant explanatory measures for D_1MFT and D_3MFT scores among both female and adult male prisoners and number of cigarettes smoked per day significantly explained D_1MFT and D_3MFT scores among females.

There is mixed evidence for a direct relationship between smoking and dental caries with the literature covering the role of several contributing factors such as age, oral hygiene, dental attitudes and dental attendance patterns [200]; to some extent, evidence for multiple factors were evident among the female prisoners studied (see Table 4.20). Alongside smoking, age, dental-related attitudes and IDU significantly explained the variation in D_1MFT and D_3MFT scores among females and there was some indication ($p = 0.143$) that time imprisoned additionally explained higher D_3MFT scores. Other studies have shown nicotine to be ingrained in the prison culture and that both male and female prisoners view it as a key resource to manage stress in the prison setting with some taking up smoking [201], or smoking more [202]. In Scotland, there are plans in place to introduce legislation to ban smoking, although one study from the US has already documented prisoners' expression of autonomy by ignoring an imposed ban [203]. With the complex reasons surrounding smoking in prison settings it is incumbent on services to consider how best to support inmates (and indeed prison staff) to quit smoking. The data for all prisoners combined also indicated smoking was moderately correlated with higher depression scores (see Appendix Table 9.7) and whilst a meta-analysis by Kisely *et al.* [204] has evidenced an association between depression and higher caries scores, the causal mechanisms are not yet understood.

Substance use is widespread among the prisons population and in Scotland, during 2010/11, 73% of prisoners entering prison (at two annual time points) tested positive for illegal drug use [205]. In this study, problematic drug use (IDU) best explained the variation in dental caries scores among adult males and females. Whilst a link between substance misuse and sugar consumption has been proposed by others (see section 2.3.9.4), frequent sugar consumption patterns in the home or prison setting were not correlated with either rehabilitation or IDU. IDU was correlated with age, gender, number of times remanded or sentenced, CRF health conditions, an indication of medicinal-related dry mouth, homelessness experience, and smoking (see Appendix Table 9.7). Prisoners' experiences of indication of dry mouth, homelessnesss and smoking are previously described. Multiple studies have evidenced female prisoners as particularly vulnerable to drug misuse [206] however our understanding of how the prison setting influences drug use patterns is more limited. Qualitative data have shown drug use is employed as a coping strategy necessitated by the prison environment although the social isolation prisoners were seeking to escape deteriorated further [207]. Another review documented the prison setting as an environment where drug use patterns changed by necessity and the result was greater exposure to more addictive drugs [208].

5.7 Dental health-related behaviours

A number of dental-health related behaviours were included: attendance at the prison dentist, time since last attendance, sugar consumption between meals, and toothbrushing with fluoride toothpaste. Time since last dental attendance did not significantly explain either caries score in any of the three populations. The remainder of the dental-health related behaviours contributed, to mixed degrees, to the models explaining variation in caries scores among the male populations (see Table 4.21 and Table 4.22).

Attendance at the prison dentist significantly explained higher D_3MFT scores among adult males and higher D_1MFT scores among male young offenders. Attendance at the prison dentist also marginally improved the explanatory model for D_1MFT scores for adult male offenders. It is important to note that prisoners in Scotland must first make a request (by self-referral form) before being seen by a dentist and typically the waiting lists for dental treatment necessitate priority to those requiring urgent care. It is therefore perhaps unsurprising that those with severe caries were more likely to have attended the prison dentist for the treatment of their dental disease. While it is possible that the explanation for increased dental caries is irregular attendance, this supposition, calls once more into question the role of regular dental attendance and the promotion of dental health. Therefore, to explore this more fully, it is important to consider other dental health behaviours such as sugar consumption and fluoride toothpaste use, which affect dental caries experience [209].

In the present study, avoiding sugar consumption between meals in the *home* setting came close to (p = 054) significantly explaining lower D_1MFT scores among adult males, and, again for adult males in the home setting, brushing with fluoride toothpaste significantly explained lower D_3MFT scores. There was no evidence that either behaviour in the *prison* setting was associated with D_1MFT or D_3MFT experience, nor was there any evidence that these behaviours in the *home* setting were associated with either score among females or the male young offender population. One of the unique contributions from this thesis is the examination of the change in oral health-related behaviours between the two settings of home and prison. Toothbrushing behaviours were significantly improved in the prison setting for long-stay adult males and male young offenders whereas there was no change for females. Adult males reported less consumption of sugars between meals whilst inside prison, with no significant difference among females and male young offenders.

It is possible, for the long-stay population, the data captured increased knowledge and understanding of the two behaviours and their role in oral health as a result of an intervention in that prison [179]. The adult males are also characteristic of long-stay prisoners and would have had opportunity to become accustomed to and habitualise health promoting behaviours. The importance of "contextual cues" in the formation of routine behaviours have been extensively reviewed for a variety of settings [210]. The findings for toothbrushing routines corroborate the SOHIPP qualitative work where some prisoners identified the prison structures and systems as a stabilizing force where their daily routine was regimented and they could more easily adopt oral health improvement behaviours [70].

Therefore, it may be suggested that alongside other risk indicators, such as IDU, fluoride toothpaste use and reported sugar consumption were factors in obvious caries experience, and in particular, among the adult male populations. This has some importance when considering the role of dental attendance for the promotion of oral health in this specific population with respect to the treatment of oral disease. Within dentistry there is well documented evidence that exposure to fluoride (at safe concentrations) e.g. in water supply [211] or in the form of fluoride varnish [212] provides evidenced benefits in terms of effective reduction in new dental caries. Use of fluoride toothpaste has been shown by a number of studies to significantly reduce new caries experience and moreover good toothbrushing practices will also ensure plaque is being removed [213]. There is also some evidence that, among children and adolescents [214], the effect of fluoride toothpaste is dose-dependent when comparing concentrations of 1,000 ppmF (0.10%) and above with 250 ppmF. In the UK, fluoride concentrations in over-the-counter products are regulated with a maximum of 1,500 ppmF allowed. However, higher concentration products are available by prescription [213].

5.8 Dental health-related attitudes

Among female prisoners, preferences for extractions for front teeth, rather than restorative treatment, significantly explained higher D_1MFT score and preferences for extractions for back teeth significantly explained higher D_3MFT scores. Conversely, attending for a check-up was associated with significantly lower D_1MFT and lower D_3MFT scores when compared to those attending with problems with their teeth or gums. Dental attitudes were not associated with either caries outcomes among the male populations, however other studies of UK prisoners have found male prisoners are more likely to attend for emergency dental treatment [94].

The cost of dental treatment or accessibility of dental services was not assessed here, although a separate qualitative study embedded within the SOHIPP programme did find, that on liberation, the cost of missed appointments and private treatment were barriers expressed by Scottish prisoners alongside a number of other patient factors; conversely, collaborations between dental and throughcare services enabled prisoners to access dental treatment [70].

5.9 Psychosocial health

From this study increases in the Modified Dental Anxiety Score (MDAS) was significantly associated with higher D_1MFT and D_3MFT scores among the male young offender population alone. There was no evidence of an association between the Center for Epidemiologic Studies Depression (CES-D) scale and D_1MFT or D_3MFT scores.

The most recent ADHS in the UK [168] highlighted the relationship between increased dental anxiety and reduced dental attendance. However, for this study population, the dental anxiety score was not associated with the measure for attendance for preventive treatment (p = 0.969), time since last dental attendance (p = 0.760) or attendance at the prison dentist (p = 0.380). This was furthermore confirmed in the final models for young offenders, which showed very little explanatory effect of the MDAS score.

As noted above other psychological stress markers were evident among this population e.g. high proportions of all three prisoner groups smoked cigarettes, and this study has highlighted the broader ill health experiences experienced by the population. One possible explanation for the findings is desensitization to dental anxiety as a result of the significant and damaging life events experienced by this population [184, 187], however to truly understand this further research embedded within the interdisciplinary framework of life course epidemiology is needed.

6 Reflections: strengths and limitations

The SOHIPP oral health survey (previously defined) comprised a non-probabilistic cross-sectional survey sample. In this study, budgetary constraints limited the staffing resources available for data collection which in turn limited the number of prisoners that could be examined, thus a sample size of 300 (100 participants per prison) was sought from the outset. A retrospective power analysis (see Appendix 9.9.6) determined the study had sufficient power to detect moderate effect sizes, however there was less power to detect differences in the analyses of the three individual prisons and it was therefore prudent to not over-interpret the results from the prison-specific analyses.

In addition to those unable to consent, security restrictions also precluded the possibility of examining those deemed of high security risk. Furthermore, logistical constraints limited the number of days that could be allocated for study visits thus, in order to maximize the number of prisoners that could be seen, randomized sampling methods were not feasible and not all residential halls were visited. The sampling strategy therefore precludes the generalization of results to predict caries scores outside the study population and is limited to a snapshot of the study measures considered. Since there were few (n < 20) young female offenders gender-matched comparisons between the younger populations were also unreliable. Nevertheless, we did successfully recruit a reasonably large and diverse population of prisoners with excellent response rates across all domains measured (see Appendix 9.6). The sampling frames and strategies adopted also allow some confidence that findings are reasonably reliable estimates of how indicators for D_1MFT and D_3MFT varied between the studied populations.

The three prison sites were specifically selected to ensure the sample included both males and females, young offenders and adults, and those incarcerated for both short and long-term periods. One of the goals of the survey was to include as many people as possible, thus recruitment was sought from within the residential halls; the alternative location would have been medical centres in the prisons however this would have had a greater impact on the prison environment and necessitated greater resources for the secure transport of prisoners to, and from, the centres. By attending the residential halls we also avoided limiting the sample to individuals presenting for dental treatment. Our experience concurs with previously documented research experiences that literacy skills in the prison population can be a barrier to participation in paper based studies [71].

The examiners and researchers were aware of this from the outset and sought to support as many prisoners as possible e.g. by asking if participants needed assistance, checking forms for completeness and interviewing participants if there was a lot of missing data. The design of the data collection form was also assessed by oral health improvement staff and prison healthcare managers to ensure the wording was understandable. Despite these efforts to ensure the survey was easily accessible, it is possible the most vulnerable prisoners were too embarrassed to take part in the survey. Beyond the recruitment strategy there are additional methodological limitations which should be noted.

For the dental examinations, two examiners attended each of three prisons and the dental charts were scribed by the accompanying researchers; both examiners and researchers attended the ICDAS training (see section 3.6.1) which was delivered by an experienced ICDAS coordinator. Both dental examiners were practising dentists and additionally had previous experience of epidemiological fieldwork e.g. the National Dental Inspection Programme. Whilst the training and data collection form was designed to ensure standardization in examination procedures and data recording it is prudent to acknowledge this study does not a measure of intra- or inter-examiner reliability since no repeat examinations were performed. Thus the concordance between the two examiners is unknown and in particular it is noted there may have been systematic errors in caries assessments made.

The caries outcome scores for this study were derived from dental examination data recorded using the International Caries Detection and Assessment System (ICDAS) clinical visual diagnostic criteria [19]. The ICDAS methods require the use of compressed air for the diagnosis of the earliest detectable lesions (ICDAS caries code 1) however security restrictions prevented us from taking compressed canisters into the prisons residential halls. Whilst this may impact the sensitivity of the measures this limitation is restricted to early enamel lesions. Furthermore, the ICDAS caries codes were amalgamated into summary scores for analyses in this study and caries code 1 to 3 are only applicable to D_1MFT scores (see Table 3.2), where disease experience could be underestimated as a result of the modified method. No other comprise to the procedures for ICDAS assessment were made since plaque was removed through brushing. Conversely, the D_3MFT summary score, capturing caries into the dentine (i.e. ICDAS caries codes 4 to 6), may have been underestimated due to misclassification of teeth at earlier stages of disease and in particular ICDAS caries levels 2 and 3 [29]. The ICDAS training (see section 3.6.1) included explanations and examples of the distinction between caries with and without underlying dentine shadowing; nevertheless it is possible that upon visual examination caries appeared to be confined to the early stages of disease when in fact the underlying dentine was also compromised. Such misclassifications occur most frequently at ICDAS caries levels 2 and 3 [29].

As with other surveys, misclassification of missing teeth, when not missing *due to caries*, would result in overestimation of caries experience. Periodontal (gum) disease is another common oral health condition both in prisoners [94] and in the general population [215], which in its severe form will result in loss of dentition; trauma is another potential leading cause of tooth loss in this population; and, more generally, elective loss of teeth for the purposes of orthodontic treatment is a common reason for missing dentition [216]. The dentists who performed all examinations were specifically trained in the use of ICDAS and furthermore both dentists had experience of conducting national surveys. It is further acknowledged that broken or chipped dental surfaces (i.e. partially missing) could not be recorded using the ICDAS recording system which is of note in a population where dental trauma may be more commonplace [217]. Since this thesis is primarily focused on caries experience these limitations will not severely impact the validity of the findings. As radiographs were not undertaken, it is possible interdental caries was missed, thus caries may have been underestimated.

The survey included a number of valid and reliable scales as well as questions recommended by the World Health Organization (WHO) for oral health surveillance [145] and adopted in the United Kingdom, Adult Dental Health Survey (UKADHS) 1998 [110]. Additional content included the Modified Dental Anxiety Scale (MDAS) [148] and Center for Epidemiologic Studies Depression Scale (CES-D) [149] and, whilst untested in a prisons population, were chosen due to their good reliability, validity and precision in detecting oral health impacts. Not all SOHIPP measures relevant for dental caries were assessed in the present study. Plaque (see Appendix 9.9.5) was excluded from the analyses since this was an intermediate measure and the snapshot data from the survey did not provide sufficient information to allow a determination of how well the participant managed plaque over time. Some of the dental attitude measures could not be analysed in a meaningful way and were not included. Social engagement could not be accurately defined over time (see Appendix

9.9.3). Data for dentures (see Appendix 9.9.4) were also excluded however it is noted the ICDAS captures data for missing dentition and these data were included within the missing teeth (MT) component of both summary scores.

One of the concerns of the survey was the length of the form and its acceptability to prisoners. The full versions of the Oral Health Impact Profile (OHIP) (49-items) and Modified Dental Anxiety Scale (MDAS) were deemed to be too long for this population. The shortened versions were adopted in a recent survey of homeless population [170] and found to be acceptable. Nevertheless, it is possible the shortened tools were not sufficiently sensitive for use with prisoners.

We did not find any association between dental attendance behaviours and dental caries experience. In Scotland, dental recall intervals are based on the National Institute for Health and Care Excellence (NICE) guidelines which are structured on a risk assessed dependent recall period where the maximum intervals are 24 months for patients 18 years or older, and 12 months for those less than 18 years [218]. In this study a risk assessment for dental recall was not completed and only five individuals in the sample population were aged under 18 years of age; given the prevalence of caries found (see section 4.4) it is likely the effects of irregular dental attendance were underestimated.

An intended aim of the study was to develop and compare predictive models of the risk indicators which explained caries severity i.e. early caries through to frank caries experience. However there were insufficient observations to be able to distinguish prisoners with early stage disease (see Appendix 9.7.1 for details). Similarly, less than 3% of prisoners were caries-free (see Appendix Table 9.3) thus it was not feasible to dichotomize the outcome scores for logistic regression analyses. Moreover, both outcome scores and some potential indicators had non-normal distributions and, whilst these are typical characteristics of dental [219] and medical data [220], these features violated assumptions of the non-parametric statistical tests supplemented to this thesis (e.g. Kruskal Wallis) thus making the test results less reliable, especially where prison-specific findings are reported since there were small sample numbers at the outset. The outcome data for this study showed clear features of heteroscedasticity (non-constant variance) in the residuals.

In consideration of the above data features it was important to identify analyses methods which would give reliable estimates of effect for the relatively large number of potential indicators to be investigated and which would permit conclusions to be drawn regarding the differences of effects, if such differences existed, between the populations of study. This study has used robust regression instead of ordinary least square regression methods which allows for more confidence – both for the univariable and multivariable regression results – that the effect sizes reported are reliable estimates which account for the non-constant variance observed.

Despite the statistical analysis strategy and use of a number of widely used survey tools, the multivariable regression did not identify informative explanatory models for caries experience among male young offenders, with very little of the variation in outcome scores explained. For this population, the lack of discrimination within some of the potential indicators meant it was difficult to identify differences which could be compared in the search of indicators to explain caries experience (e.g. unemployment, social occupational classification) - although this reasoning did not apply to all measures. The findings indicate the use of research tools designed for adults is not appropriate in eliciting responses from a young male offender population.

Lippman *et al.* [221] have highlighted adult-based survey designs can be incompatible with the cognitive and psychosocial development of young respondents and reported the prevailing theory (Krosnicks satisficing theory) which explains how a young person might reconcile the two with the result being less ‘accurate and reliable’ responses. Lippman proposed a range of resolutions including better designed tools, sampling methods, and the use of mixed and specialized methods e.g. cognitive interviewing. Whilst it is incumbent on funders and researcher alike to recognize the added cost of improved research design it is apparent the *status quo* of recycling survey designs for adults is not sufficient to better our understanding of a young populations needs.

7 Conclusions & Recommendations

7.1 Main findings

This thesis sought to examine how dental caries experience and its related risk indicators vary between vulnerable prisoner populations with a view toward informing recommendations for future oral health improvement policies. Whilst community-acquired risk factors, often resultant from poor socioeconomic backgrounds, are relatively well documented, few published studies have empirically assessed differences between sub-populations of prisoners. This study sought to address this knowledge-gap by comparing three Scottish prisoner populations of females, long-stay adult males, and male young offenders.

Across all three populations investigated, high dental caries experience was ubiquitous and decayed and missing teeth contributed the most to total caries experience. Amongst adults, other than age, intravenous drug use was the primary risk indicator of caries experience, irrespective of gender. The collective results also provide evidence for partially divergent explanatory models for caries outcomes between females and males.

For female prisoners, smoking and dental-related attitudes were significant risk indicators for caries outcomes; there was limited evidence that time imprisoned also explained caries into dentine experience. The independent analyses found non-resident mothers and females who did not complete education or a history of multiple remanded stays in prison also had greater caries experience.

For adult males, disadvantaged living circumstances and oral health-related behaviours in the home setting were explanatory risk indicators for caries experience. However, living circumstances were also associated with intravenous drug use, suggesting these social determinants may have acted as the ‘causes of the causes’ of caries experience. The independent analyses again found non-resident fathers and those who smoked had greater caries experience.

From the risk indicators identified it may be possible to develop gender-specific oral health improvement interventions for the adult Scottish prisons population and be able to target those most at risk. Further work is needed to understand the risk indicators for caries experienced by young offenders.

7.2 Recommendations

In order to promote the dental health of people in Scottish prisons, there is a need to consider both upstream and downstream strategies for oral health improvement.

It is recommended that policy should address the need for:

1. Prisoners with a history of substance misuse to be recognised as a priority group for future oral health improvement programmes;
2. Needs assessments to be conducted to inform our understanding of the dental treatment need and reasons for dental extractions;
3. Throughcare services to be readily available to secure opportunities which meet the needs of these prisoners as they transition to the community setting;
4. Research funding to be prioritised for studies aimed at better understanding the risk indicators for caries experienced by young offenders.

Within the prison estate, there is a strong need for strategies to be put into place to strengthen the prevention of 'dental ill-health':

1. Oral health improvement strategies are developed, within an inter-agency collaboration framework, between oral health promotion and drug rehabilitation services and smoking cessation programmes;
2. Effectively identify and reach those most at risk e.g. prisoners with a history of substance misuse and/or heavy smokers;
3. Oral health promotion should recognise the importance of, and seek to elicit reasons for, dental-related attitudes, particularly amongst females, and behaviours, particularly amongst males, and respond with a person-centred approach, tailored to the needs of the individual;
4. Consideration is given to the implementation of educational opportunities for female offenders with a history of poor school attendance;
5. Through-care programmes are considered to ensure prisoners are supported as they transition back to the community and, for adult males in particular, clear sign-posts and guidance is given for housing support services.

7.3 Future research

The original analysis undertaken did not explain a substantial amount of the variation in dental outcome scores for male young offenders. It is suggested future studies should consider methodologies which are tailored for this younger population and with oversampling for young female prisoners in order to examine differences in modifiable risk indicators in these formative years of development. A realistic evaluation should also consider dental caries in its constituents of decayed, missing and filled dentition since risk factors may differ between these specific outcomes. Future work should also be sensitive to changing social norms, for example, New Psychoactive Substances or 'legal highs' have been highlighted as a particular emerging issue for prison authorities [222] and may have different implications for dental caries experience. The recommendation for sugar-free methadone prescribing remains valid, however the work reported here has highlighted the potential impact from prescribed medicines where dry mouth is indicated as a side effect. Whilst an indication for dry mouth was confirmed for females and not adult-males, current prescribing practices would suggest an intervention would be just as applicable to both genders. Further work needs to be undertaken to understand how much medicinal-related dry mouth impacts this population and how the prison setting modifies this potential risk indicator. Finally, this thesis has highlighted that risk indicators for dental caries are modified within the prison setting but not necessarily for all populations, the data is however limited and a comprehensive assessment of how the social determinants of health may be modified will require data collection before, during, and after, exposure to the prison environment.

8 References

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9 Appendices

9.1 Literature review: search strategies

9.1.1 MEDLINE® via EBSCOhost® search strategy

1. MM “Dental Care”
2. MH “Dental Caries Susceptibility”
3. MH “Root Caries”
4. MH “Dental Caries+”
5. MH “Dental Caries Activity Tests”
6. MH “Cariogenic Agents”
7. MM “Oral Health”
8. MM “Tooth Diseases”
9. MH “Prisoners”
10. MH “Prisons+”
11. MH “Criminals”
12. MH “Dental Health Services+”
13. MH “Dental Health Surveys+”
14. MH “Health Education, Dental”
15. MH “Tooth Diseases+”
16. MH “DMF Index”
17. MH “Tooth Loss”
18. MH “Toothbrushing”
19. MH “Dental Plaque”
20. MH “Diet, Cariogenic”
21. MH “Dental Restoration Wear”
22. MH “Dental Restoration Repair”
23. MH “Dental Restoration, Temporary+”
34. MH “Dental Restoration, Permanent+”
25. MH “Dental Restoration Failure”
26. 9 OR 10 OR 11
27. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25
28. 26 AND 27
29. Limit 28 to English language

93 results *retrieved 14th December 2012*

14 results *retrieved 22nd August 2015 (Date of publication limit: 20120101-20141231)*

9.1.2 Embase via OvidSP search strategy

1. exp prisoner/
2. exp prison/
3. exp offender/
4. exp juvenile delinquency/
5. 1 or 2 or 3 or 4
6. exp dental caries/
7. exp tooth disease/
8. exp anticaries agent/
9. exp dentin/
10. exp tooth plaque/
11. exp preventive dentistry/
12. exp stomatognathic system/
13. 6 or 7 or 8 or 9 or 10 or 11 or 12
14. 5 and 13
15. english.lg.
16. 14 and 15

98 results *retrieved 13th December 2012 (1980 to 2012 database)*

48 results *retrieved 22nd August 2015 (Limit: 2012:2015.(sa_year)*

9.1.3 CINAHL Plus via EBSCOhost® search strategy

1. MW caries
2. MW "dental health"
3. MW "oral health"
4. MW "tooth demineralization"
5. MH "Dental Caries"
6. MM "Tooth Loss"
7. MM "Dental Care"
8. MM "Dental Health Services"
9. MM "Research, Dental"
10. MM "Dental Hygiene"
11. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10
12. MW prisoners
13. MW criminal
14. MW offenders
15. MM "Correctional Health Services"
16. MW correctional
17. MH "Juvenile Offenders"
18. MM "Prisoners"
19. 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18
20. 11 AND 19

49 results *retrieved 13th December 2012*

8 results *retrieved 22nd August 2015 (Limit: Publication Year: 2013-2015)*

9.1.4 Applied Social Sciences Index and Abstracts (ASSIA) via ProQuest search strategy

#1. ("preventive dental care" OR "oral health" OR "dental health education" OR "tooth loss" OR "caries" OR "dental caries" OR "oral health care" OR "dental care" OR "toothbrushing").su

#2. ("private prisons" OR "maximum security prisons" OR "long term prisoners" OR "bruchsal prison" OR "prison service" OR "full sutton prison" OR "first time offenders" OR "prison service agency" OR "detained juvenile offenders" OR "ex-offenders" OR "federal prisons" OR "dangerous offenders" OR "ex-prisoners" OR "convicted offenders" OR "offender/offenders" OR "offenders" OR "open prisons" OR "prisons" OR "international centre for prison studies" OR "privatized prisons" OR "pentonville prison" OR "remand prisoners" OR "prison culture" OR "local prisons" OR "convicted rape offenders" OR "channings wood prison" OR "life imprisonment" OR "prisonization" OR "prison act 1952" OR "barlinnie prison" OR "prison health services" OR "prison adjustment questionnaire" OR "prison services" OR "dying offenders" OR "prisoners" OR "crime and criminals" OR "imprisoned men" OR "remand prisons" OR "kairos prison ministry" OR "imprisonment" OR "downview prison" OR "disabled young offenders" OR "female offenders" OR "prisoner rehabilitation" OR "male prisons").su

#3. 1 AND 2

.su=subject heading

1 result *retrieved 14th December 2012 (1987 – current database)*

1 result *retrieved 23rd August 2015 (limit: publication date 2012 onwards)*

9.1.5 SCOPUS via SciVerse search strategy

1. gaol*.ti,abs,kw
2. prison*.ti,abs,kw
3. "penal institution*".ti,abs,kw
4. jail*.ti,abs,kw
5. "detention program*".ti,abs,kw
6. "detention facilit*".ti,abs,kw
7. incarcerate*.ti,abs,kw
8. recidivism.ti,abs,kw
9. inmate*.ti,abs,kw
10. felon*.ti,abs,kw
11. offender*.ti,abs,kw
12. custod*.ti,abs,kw
13. convict*.ti,abs,kw
14. detaine*.ti,abs,kw
15. remand*.ti,abs,kw
16. criminal*.ti,abs,kw
17. correctional.ti,abs,kw
18. penitentiar*.ti,abs,kw
19. "youth rehab*".ti,abs,kw
20. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19
21. caries.ti,abs,kw
22. cario*.ti,abs,kw
23. dmf*.ti,abs,kw
24. icdas*.ti,abs,kw
25. "decay* teeth" .ti,abs,kw
26. "decay* tooth" .ti,abs,kw
27. "dental health".kw
28. "oral health".kw
29. "dental survey".kw
30. dental.kw
31. 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30
32. 20 and 31

ti=title; abs=abstract; kw=keyword

392 results *retrieved 13th December 2012*

63 results *retrieved 22nd August 2015 (limit: publication year 2013, 2014, or 2015)*

9.1.6 PsychARTICLES via APA PsycNET® search strategy

1. gaol*.ti,abs,kw
2. prison*.ti,abs,kw
3. "penal institution*".ti,abs,kw
4. jail*.ti,abs,kw
5. "detention program*".ti,abs,kw
6. "detention facilit*".ti,abs,kw
7. incarcerate*.ti,abs,kw
8. recidivism.ti,abs,kw
9. inmate*.ti,abs,kw
10. felon*.ti,abs,kw
11. offender*.ti,abs,kw
12. custod*.ti,abs,kw
13. convict*.ti,abs,kw
14. detaine*.ti,abs,kw
15. remand*.ti,abs,kw
16. criminal*.ti,abs,kw
17. correctional.ti,abs,kw
18. penitentiar*.ti,abs,kw
19. "youth rehab*".ti,abs,kw
20. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19
21. caries.ti,abs,kw
22. cario*.ti,abs,kw
23. dmf*.ti,abs,kw
24. icdas*.ti,abs,kw
25. "decay* teeth" .ti,abs,kw
26. "decay* tooth" .ti,abs,kw
27. "dental health".ti,abs,kw
28. "oral health".ti,abs,kw
29. "dental survey".ti,abs,kw
30. dental.kw
31. oral.kw
32. 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31
33. 20 and 32

5 results *retrieved 14th December 2012 (1894-current database)*

1 result *retrieved 23rd August 2015*

9.2 SOHIPP ethics approval

NHS Fife | NHS Forth Valley | NHS Tayside

East of Scotland Research Ethics Service

Fife & Forth Valley Research Ethics Committee
Research Ethics Office
Residency Block, Level 2
Ninewells Hospital & Medical School
DUNDEE
DD1 9SY

Professor Ruth Freeman
Professor of Dental Public Health Research
DHSRU, MacKenzie Building
Kirsty Semple Way
Dundee
DD2 4BF

Date:	12 March 2010
Your Ref:	
Our Ref:	FB/10/S0501/10
Enquiries to:	Miss Fiona Bain
Extension:	Ninewells extension 32701
Direct Line:	01382 632701
Email:	fionabain@nhs.net

Dear Professor Freeman

Study Title:	**The Scottish Oral Health Improvement Prison Programme (SOHIPP): Developing, implementing and evaluating an oral health preventive programme for prison populations in Scotland: A survey of prisoners' oral health and a qualitative study of prisoners' oral health concerns.**
REC reference number:	**10/S0501/10**
Protocol number:	**1.3**

Thank you for your letter of 26 February 2010, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Vice-Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, ***subject to the conditions specified below***.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

POSITIVE ABOUT DISABLED PEOPLE

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk. *Where the only involvement of the NHS organisation is as a Participant Identification Centre, management permission for research is not required but the R&D office should be notified of the study. Guidance should be sought from the R&D office where necessary.*

Sponsors are not required to notify the Committee of approvals from host organisations.

Other conditions specified by the REC

In the Participant Information Sheets, please amend the reference to the 'Fife & Forth Valley Research Ethics Service" to the "Fife & Forth Valley Research Ethics Committee". These should be submitted for our records.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	Version	Date
Protocol	1.3	11 January 2010
Investigator CV		06 January 2010
Evidence of insurance or indemnity	Renewal Date 01/08/2010	19 August 2009
Summary/Synopsis		
Interview Schedules/Topic Guides	1.4	06 January 2010
CV - Mr Derek Richards		07 January 2010
CV - Ms Patricia Smith		07 January 2010
Email from Jeannette Kalsgaard re sponsor letter		07 January 2010
Letter from Funder - Scottish Government		07 January 2010
flyer for Oral Health Survey	1.0	05 January 2010
Poster for Oral Health Survey	1.0	05 January 2010
Poster for Qualitative Study of Prisoners' main concerns	1.0	05 January 2010
flyer for Qualitative Study of Prisoners' main concerns	1.0	07 January 2010
Questionnaire: A Survey of Prisoners' Oral Health	2.0	11 January 2010
REC application		11 January 2010
A Survey of Prisoner's Oral Health 2010	2	11 January 2010
Letter from Sponsor	Updated	25 January 2010
Participant Information Sheet: Qualitative study of prisoners' oral health concerns	1.9	22 February 2010
Participant Consent Form: Qualitative study of prisoners' oral health concerns	1.5	22 February 2010
Participant Consent Form: A survey of prisoners' oral health	1.2	22 February 2010
Questionnaire: Questionnaire of prisoners' oral health		

Document	Version	Date
Response to Request for Further Information		26 February 2010
Participant Information Sheet: Survey of prisoners' oral health	1.9	22 February 2010

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

10/S0501/10	**Please quote this number on all correspondence**

Yours sincerely

for **Mr Gavin Costa**
Chair

Enclosures: "After ethical review – guidance for researchers"

Copy to: Research & Innovation Services, University of Dundee
NHS Tayside R&D office

9.3 SOHIPP information poster

The Scottish Oral Health Improvement Prison Programme

A Survey of Prisoners' Oral Health

Did you know?....

That the Scottish Government wants to make the teeth, gums and mouths of prisoners better? Could you help us?

What is involved?

- You'll be asked to fill in a consent form.
- You'll have your teeth, gums and mouth examined by a trained dentist. If you have dentures they will check if they fit.
- You'll be asked to fill in a questionnaire about your dental health, how you care for your teeth, if you are fearful of dental treatment, if your teeth bother you and how your oral health affects your mood.

What happens to the information once it has been collected?

The information will be analysed by the researcher at the University of Dundee.

What happens if I don't want to take part?

Nothing.

What should I do if I want to take part?

If you are interested and want more information please fill in the form below and hand it to XXXXXX

Version 1.0: 05/01/2010

The Scottish Oral Health Improvement Prison Programme

A Survey of Prisoners' Oral Health

SOHIPP

I would like to find out more about the **dental health survey**

Name: ____

Version 1.0: 05/01/2010

9.4 SOHIPP participant information sheet & consent form

PARTICIPANT INFORMATION SHEET

The Scottish Oral Health Improvement Prison Programme

A SURVEY OF PRISONERS' ORAL HEALTH

We invite you to participate in a research project. We believe it to be of potential importance. However, before you decide whether or not you wish to participate, we need to be sure that you understand first why we are doing it, and secondly what it would involve if you agreed. We are therefore providing you with the following information. Read it carefully and be sure to ask any questions you have, and, if you want, discuss it with others. We will do our best to explain and to provide any further information you may ask for now or later. You do not have to make an immediate decision.

What is the study about?

Most prisoners have poor teeth and gums (oral health). The Scottish Government wants to make the oral health of prisoners better. Researchers from the University of Dundee together with NHS Health Boards have been asked to find out about prisoners' oral health and how their oral health affects them. So we can do this we need to look at your teeth, gums, mouth and dentures. We will ask you to fill out a questionnaire about what you think about your teeth, about going to the dentist and if your mouth bothers you. Can you help us?

Who will take part?

All prisoners who have read this information sheet and who have given their written consent to take part.

What would I have to do?

You will have your teeth, gums and mouth examined by a trained dentist. If you have dentures the dentist will check if they fit. You

Page | 1

will also be asked to complete a questionnaire to find out what you think about your dental health, how you care for your teeth, if you are fearful of dental treatment, if your teeth bother you and how your oral health affects your mood.

Will everyone be asked to do the same things?

Yes everyone will be asked to do the same things.

Will what I say be confidential?

Yes all the information about your dental health and what you feel about your teeth, gums and mouth will be confidential. What you say will not be passed on to your doctor, dentist prison psychiatrist or prison staff unless you are depressed, feel you may harm yourself or others or disclose any criminal activity. However during the study it will be necessary for the research team to check the information gathered so that the survey is performed to the highest possible standard.

Do I have to take part?

No. It is up to you. If you agree you will sign a consent form showing that you understand what is involved and that you have agreed to take part. Not all people who volunteer will automatically be interviewed. It depends how many ask to take part.

Can I change my mind and withdraw at any time?

Yes. You can withdraw at any time you like without giving a reason and your care from prison staff and health staff will not be affected.

What's in it for me?

We cannot promise the research will help you personally but it may help to improve the dental health services and how prisoners look after their teeth.

How do I find out more about the study?

You can ask a member of the prison staff to pass on your questions to the research team. The research team will either answer your question or, if needed, arrange to contact you directly as soon as possible.

Will I find out the results of the study?

When the research is finished we will send you a short report. If you want a full report ask prison staff who will arrange this for you.

What if there is a problem?

If you believe that you have been harmed in any way by taking part in this study, you have the right to pursue a complaint and seek any compensation through the University of Dundee who are acting as the research sponsor. Details of this are available from the research team.

Who has reviewed this study?

The Fife and Forth Valley Research Ethics Committee, which has responsibility for scrutinising all proposals for medical research on humans in NHS Fife, NHS Forth Valley, NHS Tayside and University of Dundee has examined the proposal and has raised no objections from the point of view of medical ethics. It is a requirement that your records in this research be made available for scrutiny by monitors from NHS Tayside whose role is to check that research is properly conducted and the interests of those taking part are adequately protected.

Thank-you for taking the time to read this information sheet and for considering taking part in this study.

Dental Health Services & Research Unit, University of Dundee

Version 3.1 10/09/2010

The Scottish Oral Health Improvement Prison Programme

WRITTEN CONSENT FORM: A SURVEY OF PRISONERS' ORAL HEALTH

Participant number: ☐☐☐☐☐

PLEASE INITIAL ALL BOXES AND SIGN YOUR NAME TO CONFIRM THAT

- The researcher has explained to me what is involved in the study. Please initial box ☐
- I have read and understand the information sheet (version 3.1: 10/09/2010)
  Please initial box ☐
- I understand that my teeth, gums and mouth will be examined.

  Please initial box ☐
- I understand that I can withdraw from the study at any time and for any reason and that this will not affect the care that I receive from prison or health staff.

  Please initial box ☐
- I understand that the prison authorities will be notified if I become distressed or say anything about behaviour likely to be of harm to myself or others.

  Please initial box ☐

- I have had the chance to ask questions about the study.

  Please initial box ☐

- I agree to take part in the study.

  Please initial box ☐

Name of participant ______________________

Signature of participant ______________________

Date__________

(Please note that participants must date their own signature)

Name of researcher ______________________

Signature of researcher ______________________

Date_________

Version 3.1 10/09/2010

9.5 SOHIPP data collection form

The Scottish Oral Health Improvement Prison Programme

A Survey of Prisoners' Oral Health

SOHIPP

University of Dundee

Dental Health Services Research Unit

NHS Ayrshire & Arran | NHS Forth Valley | NHS Greater Glasgow and Clyde | NHS Highland | NHS Lanarkshire | NHS Tayside | NHS Health Scotland

Participant number: ☐☐☐☐☐☐☐ Today's date: ☐☐ / ☐☐ / ☐☐

Prison name: ______

1. ABOUT YOU

Gender: ☐ Male ☐ Female Date of Birth: ☐☐ / ☐☐ / ☐☐ (D D / M M / Y Y)

Ethnic origin: ☐ White ☐ Black, Black British, Black Scottish
☐ Mixed ☐ Asian, Asian British, Asian Scottish
☐ Other: ______

First language if not English: ______

What age were you when you left school? ______ years

Before coming into prison this time were you:
☐ Unemployed ☐ Training (apprentice/trainee)
☐ Employed full-time ☐ Full time education
☐ Employed part-time ☐ Part time education ☐ Casual work

If employed, what was your job title: ______

What is your marital status? ☐ Single ☐ Married/cohabiting ☐ Separated/divorced/widowed

Do you have any children? ☐ Yes ☐ No If yes, how many? ______

Was/were your child/children living with you before prison? ☐ Yes ☐ No

Previous living status

As a child/teenager were you ever in a children's institution or home? ☐ Yes ☐ No

As a child/teenager were you ever in foster care? ☐ Yes ☐ No

Before coming to prison where did you live (stay)?
☐ Own property ☐ Temporary accommodation: hostel
☐ Rented (tied) accommodation ☐ Temporary accommodation: half-way house
☐ B&B ☐ Temporary accommodation: with friends (e.g. sofa surfer)
☐ Children's institution or home ☐ Other accommodation ______
☐ With parents or family ☐ Homeless

Have you ever been homeless? [1] ☐ Yes ☐ No

If yes, how long had you been homeless? ☐ Less than 6 months ☐ Between 1 year and 2 years
☐ Between 6 months and 1 year ☐ More than 2 years

How long ago did you begin your prison sentence? ______ years ______ months ______ days

How many times have you been in prison? ______ remand ______ sentenced

How long is your current stay in prison? ☐ Less than 4 years ☐ More than 4 years

[1] Homelessness is defined as a period of time when you may had stayed with friends or a family member because you had nowhere else to go, stayed in a hostel or B&B, on the streets or in another location such as a squat, a car or any other place you did not consider home.

2. CONFIDENTIAL MEDICAL HISTORY

	Yes	No	Don't know	Prefer not to say
Are you receiving treatment from a doctor, hospital, clinic or specialist?	☐	☐	☐	☐
Are you taking or using any medicines, pills, syrups, ointments, puffers or injectors prescribed for you by a doctor? If yes, please list below:	☐	☐	☐	☐
Have you had angina?	☐	☐	☐	☐
Have you had blood pressure problems?	☐	☐	☐	☐
Have you ever had a heart attack?	☐	☐	☐	☐
Do you suffer from any infectious disease, e.g. HIV, hepatitis?	☐	☐	☐	☐
Do you have asthma or any other lung disease?	☐	☐	☐	☐
Do you have epilepsy?	☐	☐	☐	☐
Do you have diabetes?	☐	☐	☐	☐
Do you bruise or bleed easily?	☐	☐	☐	☐
Are you allergic to any medicine, foods or materials?	☐	☐	☐	☐
Are you pregnant? (if applicable)	☐	☐	☐	☐
Do you smoke cigarettes? If yes, how many per day? ☐☐☐	☐	☐	☐	☐
Do you chew tobacco?	☐	☐	☐	☐
Are there any other details you feel we should know about your medical history?	☐	☐	☐	☐

	Yes	No	Prefer not to say
Have you ever used (illegal) drugs?	☐	☐	☐
Have you ever used intravenous drugs?	☐	☐	☐
Have you taken part in a drug treatment (rehab) programme?	☐	☐	☐

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	Not anxious	Slightly anxious	Fairly anxious	Very anxious	Extremely anxious
If you went to your dentist for TREATMENT TOMORROW, how would you feel?	☐	☐	☐	☐	☐
If you were sitting in the WAITING ROOM (waiting for treatment), how would you feel?	☐	☐	☐	☐	☐
If you were about to have your TEETH DRILLED, how would you feel?	☐	☐	☐	☐	☐
If you were about to have your TEETH SCALED AND POLISHED, how would you feel?	☐	☐	☐	☐	☐
If you were about to have a LOCAL ANAESTHETIC INJECTION in your gum, above an upper back tooth, how would you feel?	☐	☐	☐	☐	☐

In the last 12 months:	Never	Hardly ever	Occasionally	Fairly often	Very often
have you ever had trouble pronouncing any words because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you felt your sense of taste has worsened because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you had painful aching in your mouth?	☐	☐	☐	☐	☐
have you found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you been self-conscious because of your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you felt tense because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
has your diet been unsatisfactory because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you had to interrupt meals because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you found it difficult to relax because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you been a bit embarrassed because of your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you been a bit irritable with other people because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you had difficulties doing your usual jobs because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐
have you been totally unable to function because of problems with your teeth, mouth or dentures?	☐	☐	☐	☐	☐

In the last week:	Rarely or none of the time (less than 1 day)	Some or little of the time (1-2 days)	Occasionally or a moderate amount of the time (3-4 days)	Most or all of the time (5-7 days)
I was bothered by things that usually don't bother me	☐	☐	☐	☐
I did not feel like eating; my appetite was poor	☐	☐	☐	☐
I felt that I could not shake off the blues even with help from my familly or friends	☐	☐	☐	☐
I felt I was just as good as other people	☐	☐	☐	☐
I had trouble keeping my mind on what I was doing	☐	☐	☐	☐
I felt depressed	☐	☐	☐	☐
I felt that everything I did was an effort	☐	☐	☐	☐
I felt hopeful about the future	☐	☐	☐	☐
I though my life had been a failure	☐	☐	☐	☐
I felt fearful	☐	☐	☐	☐
My sleep was restless	☐	☐	☐	☐
I was happy	☐	☐	☐	☐
I talked less than usual	☐	☐	☐	☐
I felt lonely	☐	☐	☐	☐
People were unfriendly	☐	☐	☐	☐
I enjoyed life	☐	☐	☐	☐
I had crying spells	☐	☐	☐	☐
I felt sad	☐	☐	☐	☐
I felt that people dislike me	☐	☐	☐	☐
I could not get "going"	☐	☐	☐	☐

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3. ORAL HEALTH AND DENTAL TREATMENT

How long ago was your last visit to a dentist (in or out of prison)?

- ☐ Less than 6 months ago
- ☐ 6 months to 1 year ago
- ☐ Between 1 year and 2 years ago
- ☐ Between 2 years and 5 years ago
- ☐ More than 5 years ago
- ☐ Never been to a dentist

Last time you went to a dentist, what made you go?

- ☐ Trouble with teeth or gums
- ☐ I went for a check-up
- ☐ I can't remember
- ☐ Other reason: ____________

At the dentist have you ever had:	Yes	No	Don't know		Yes	No	Don't know
Fillings	☐	☐	☐	Fissure sealants (coating applied to tooth)	☐	☐	☐
An injection in your gum	☐	☐	☐	General anaesthetic (gas)	☐	☐	☐
An injection in your arm	☐	☐	☐	An abscess	☐	☐	☐
X-rays	☐	☐	☐	Bridge work	☐	☐	☐
Extractions	☐	☐	☐	A scale and polish	☐	☐	☐
Laughing gas (RA)	☐	☐	☐	Dentures	☐	☐	☐
Fluoride treatments	☐	☐	☐	Crowns	☐	☐	☐

Thinking about going to the dentist:	Definitely feel like that	To some extent	Don't know	Don't feel like that
If I had toothache I'd rather take painkillers than go to the dentist	☐	☐	☐	☐
The worst part of going to the dentist is the waiting	☐	☐	☐	☐
Going to the dentist is like being processed on a conveyor belt	☐	☐	☐	☐
I'd like to know more about what the dentist is going to do and why	☐	☐	☐	☐
I don't want fancy (intricate) dental treatment	☐	☐	☐	☐
I don't like lying flat in the dental chair	☐	☐	☐	☐
I find NHS dental treatment difficult to find outside of prison	☐	☐	☐	☐

If you went to a dentist with an aching back tooth would you prefer to have it taken out (extracted) or filled (supposing it could be filled)? ☐ Filled ☐ Taken out

If a dentist said that a front tooth would have to be taken out (extracted) or capped (crowned), what would you prefer? ☐ Crowned ☐ Taken out

Which of the following do you do daily to improve your oral health? (Please tick all boxes that apply to you)		Home	Prison
Clean my teeth with a toothbrush and fluoride toothpaste		☐	☐
Don't eat or drink sugary foods and drinks between meals		☐	☐
Clean my dentures	No dentures worn ☐	☐	☐
Leave my dentures out at night	No dentures worn ☐	☐	☐

Have you ever attended the prison dentist? ☐ Yes ☐ No

What do you think about visiting the prison dentist? (Please tick all boxes that apply to you)

☐ The dentist is not here enough
☐ I have not been able to get the request form
☐ It is difficult to get an appointment
☐ I find it difficult to complete the request form
☐ I don't like the dentist here
☐ Other reason

Have you been shown how to look after your teeth and gums by someone other than prison staff whilst in prison? If yes, who?

IF YOU HAVE LOST SOME, OR ALL OF YOUR NATURAL TEETH,
WE WOULD LIKE YOU TO ANSWER THE FOLLOWING QUESTION

Have you ever had any kind of denture? ☐ Yes ☐ No

If YES, what type of denture do you have?	Yes	No		Yes	No	Sometimes
Full TOP denture	☐	☐	Do you wear it?	☐	☐	☐
Full BOTTOM denture	☐	☐	Do you wear it?	☐	☐	☐
TOP part denture	☐	☐	Do you wear it?	☐	☐	☐
BOTTOM part denture	☐	☐	Do you wear it?	☐	☐	☐

If there is anything else you want to tell us about your mouth/teeth/dentures, or going to the dentist, please use the box below

THANK YOU

If you would like to talk about any part of this survey, or any other apsects of your dental health, please contact the Health Care Team in your prison.

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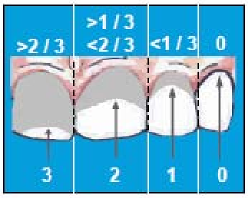
SOHIPP

The rest of this questionnaire should be completed by the clinical research team

ORAL HEALTH EXAMINATION

Oral Mucosa	No Lesion	Lesion (Monitor)	Lesion (Refer)
Lips	☐	☐	☐
Buccal Mucosa	☐	☐	☐
Tongue	☐	☐	☐
Floor Mouth	☐	☐	☐
Palate	☐	☐	☐
Fauces	☐	☐	☐

Plaque Score



Plaque coverage:

UR6	UR1	UL6
☐	☐	☐
☐	☐	☐
LR6	LL1	LL6

Dentures

Is there a denture present in the mouth? ☐ Yes ☐ No

IF YES:

Is the denture upper, lower or both?	☐ Upper only	☐ Lower only	☐ Both upper and lower

IF UPPER OR BOTH:

What is the upper denture type?	☐ Part Full	☐ Complete	☐ Implant
What is the upper denture base material?	☐ Metal	☐ Plastic	
What is the upper denture support?	☐ Tooth Borne	☐ Tissue Borne	☐ Both
What is the status of the upper denture?	☐ Intact	☐ Repair	

IF LOWER OR BOTH:

What is the lower denture type?	☐ Part Full	☐ Complete	☐ Implant
What is the lower denture base material?	☐ Metal	☐ Plastic	
What is the lower denture support?	☐ Tooth Borne	☐ Tissue Borne	☐ Both
What is the status of the lower denture?	☐ Intact	☐ Repair	

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SOHIPP Oral Health Survey: CRIB Sheet

Missing Teeth		Mesial Occlusal Distal Buccal & Lingual Surfaces (MODBL): Restoration and Sealant Codes		Mesial Occlusal Distal Buccal & Lingual Surfaces (MODBL): Caries Codes		Root Surface (R): Restoration and Sealant Codes		Root Surface (R): Caries Codes	
Code	Description	Code	Description	Code	Description	Code	Description	Code	Description
92	Pontic placed for reasons other than caries	0	Not sealed or restored	0	Sound tooth surface	F	Amalgam restoration	N	No exposed root surface.
								0	Exposed root surface present but no evidence of caries. Exposed root surface is any exposure of the root coronal to the gingival margin.
93	Pontic placed for carious reasons	1	Sealant, partial	1	First visual change in enamel	R	Not amalgam restoration		
96	Tooth surface cannot be examined: surface excluded	2	Sealant, full	2	Distinct visual change in enamel	Y	Restoration **not** intact; no evidence of caries	4	Caries on the root surface equivalent to coronal caries codes 4 or 5. This is any caries which is believed to be active on the basis of texture. An active root lesion can be almost any colour from yellow or tan through to almost black. In some circumstances it can even be difficult to tell caries from extrinsic staining. The texture is very important and the probe must be used to try to determine this. Anything which shows evidence of softening or frank cavitation should be coded as carious. **Shiny** dark areas are much less likely to be actively carious and more likely to be arrested; such areas should be coded as 'H'. Usually stained calculus and extrinsic staining will be fairly obvious, but if there is any doubt the texture is critical.
97	Tooth extracted as a result of caries	3	Tooth coloured restoration	3	Enamel breakdown, no dentine visible				
98	Tooth missing for other reasons	4	Amalgam restoration	4	Underlying dentinal shadow (not cavitated into dentine)	0	Restoration intact; no evidence of caries		
99	Unerupted	5	Stainless steel crown	5	Distinct cavity with visible dentine			6	Extensive cavity These lesions are deep and wide and probably involve the pulp.
P	Implant	6	Porcelain, gold, PFM crown or veneer	6	Extensive distinct cavity with visible dentine			9	Unscorable Code 9 should be used sparingly, and **only** if it is not clear whether or not there is any root exposure. This is most likely where there are very large deposits of calculus around lower incisors. If there is any visible root it should be coded with the appropriate letter. If there is no root surface exposed then a code 0 should be used. Only if the examiner suspects an exposed root surface, but cannot examine it should a code 9 be entered. Code 9 is also used when there has been gross destruction of the tooth and there are only roots remaining.
		7	Lost or broken restoration						
		8	Temporary restoration					H	Hard, arrested caries The surface should be glossy and hard, despite being discoloured. There has been decay, but it is now arrested.

GUIDE FOR COMPLETING SCANNABLE FORMS

This form has been designed to be machine read by a scanner. To ensure the best results during scanning, please read the following guide before completing the questionnaire.

1. For best results, please complete all pages of the survey using **black** or **blue** ink. Please do not use pencil.
2. **Check boxes:** The scanner will recognise your responses by the percentage of the box filled. You may use ticks, crosses, dots, lines or squiggles to mark your response to the questions.
3. **Correcting errors:** If you make a mistake or want to change your answer, please score out your first response and clearly mark your preferred response, i.e. enter a large X in the wrong answer and a tick in the correct one.

☐ Unemployed
☒ Employed full-time
☑ Employed part-time

4. **Text boxes:** Please write as clearly as you can, keeping all text within the box provided.
5. **Page markers:** Some of the pages on this form contain a page marker such as this:

   0730029900

   This number is used to recognise which page is being scanned. Please do not write over this number or damage it in any way.

This form has been designed in collaboration with the NES eForms Service.

NHS Education for Scotland

SOHIPP

UNIVERSITY OF DUNDEE

DENTAL HEALTH SERVICES RESEARCH UNIT

NHS Ayrshire & Arran

NHS Forth Valley

NHS Greater Glasgow and Clyde

NHS Highland

NHS Lanarkshire

NHS Tayside

NHS Health Scotland

ICDAS Chart

Participant number:

	UPPER RIGHT			55	54	53	52	51	61	62	63	64	65	UPPER LEFT		
	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
M																
O																
D																
B																
L																
R																

	LOWER RIGHT			85	84	83	82	81	71	72	73	74	75	LOWER LEFT		
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
M																
O																
D																
B																
L																
R																

If there is anything else you want to tell us about your patient's mouth/teeth/dentures, or dental attendance, please use the box below.

THANK YOU

If you would like to talk about any part of this survey, please contact the Research Team. Please return this form as previously instructed.

Cover Art: *Self-Portrait with Toothache*. Michael, HM Prison Grendon. Courtesy of The Koestler Trust.

9.6 SOHIPP databased responses

9.6.1 Socio-demographics

	N	Percentage (%)
Ethnicity		
White	277	93.0
Black, Black British, Black Scottish	2	0.7
Asian, Asian British, Asian Scottish	6	2.0
Mixed	4	1.3
Other	2	.7
Employment prior to prison		
Unemployed	198	66.4
Employed full-time	55	18.5
Employed part-time	12	4.0
Training (apprentice/trainee)	8	2.7
Full time education	4	1.3
Casual work	9	3.0
Employed (full-part- unknown)	2	.7
Unable to work	5	1.7
Relationship status		
Single	231	77.5
Married/cohabiting	33	11.1
Separated/divorced/widowed	17	5.7
Have children (size of family)		
No	125	41.9
Yes:	119	39.9
1	51	17.1
2	31	10.4
3	16	5.4
4	5	1.7
5	2	.7
6	1	.3
7	1	.3
Children living with them prior to imprisonment		
No	57	19.1
Yes	58	19.5
Accommodation just prior to prison		
Own property	46	15.4
Rented (tied) accommodation	93	31.2
B&B	3	1.0
Children's institution/home	3	1.0
With parents or family	108	36.2
Temporary acc: hostel	9	3.0
Temporary acc: half-way house	6	2.0
Temporary acc: with friends (e.g. sofa surfer)	16	5.4
Other accommodation	2	.7
Homeless	8	2.7

	N	Percentage (%)
Ever been in children's home		
No	179	60.1
Yes	95	31.9
Ever been in foster care		
No	226	75.8
Yes	33	11.1
Ever experienced homelessness		
No	172	57.7
Yes	121	40.6
Less than 6 months	42	14.1
Between 6mth and 1yr	34	11.4
Between 1yr and 2yrs	29	9.7
More than 2yrs	16	5.4

Age left school (years)	N	Percentage (%)
7.00	1	.3
9.00	2	.7
11.00	1	.3
12.00	5	1.7
13.00	8	2.7
14.00	28	9.4
15.00	95	31.9
15.28	17	5.7
15.50	1	.3
16.00	122	40.9
17.00	11	3.7
18.00	4	1.3
20.00	2	.7
21.00	1	.3

9.6.2 Imprisonment

	N	Percentage (%)
Length current stay in prison		
Less than 4yrs	140	47.0
More than 4yrs	136	45.6

9.6.3 Health status

	N (%) Yes	No	Don't know	Prefer not to say
Receiving primary or secondary care treatments	93 (31.2)	182 (61.1)	9 (3.0)	4 (1.3)
Taking prescribed medicines	132 (44.3)	145 (48.7)	3 (1.0)	4 (1.3)
Angina	10 (3.4)	272 (91.3)	9 (3.0)	0 (0.0)
Ever experienced heart attack	5 (1.7)	287 (96.3)	3 (1.0)	295 (99.0)
Blood pressure problems	30 (10.1)	251 (84.2)	14 (4.7)	0 (0.0)
Infectious disease	15 (5.0)	273 (91.6)	5 (1.7)	1 (0.3)
Asthma or lung disease	55 (18.5)	232 (77.9)	7 (2.3)	3 (1.0)
Epilepsy	7 (2.3)	289 (97.0)	0 (0.0)	0 (0.0)
Diabetes	10 (3.4)	283 (95.0)	5 (1.7)	0 (0.0)
Bruise or bleed easily	65 (21.8)	220 (73.8)	12 (4.0)	0 (0.0)
Known allergy	42 (14.1)	246 (82.6)	8 (2.7)	0 (0.0)

9.6.4 Health risk behaviours

	N (%) Yes	No	Don't know	Prefer not to say
Smoke cigarettes	224 (75.2)	69 (23.2)	1 (0.3)	0 (0.0)
Chew tobacco	4 (1.3)	284 (95.3)	1 (0.3)	0 (0.0)
Ever used (illegal drugs)	230 (77.2)	60 (20.1)	0 (0.0)	7 (2.3)
Ever used intravenous drugs	50 (16.8)	229 (76.8)	0 (0.0)	5 (1.7)
Ever taken part in drug treatment programme	57 (19.1)	237 (79.5)	0 (0.0)	1 (0.3)

9.6.5 Dental health-related behaviours

	N	Percentage (%)
Time since most recent dental attendance		
Less than 6mth ago	89	29.9
6mth to 1yr ago	47	15.8
Between 1yr and 2yrs ago	85	28.5
Between 2yrs and 5yrs ago	43	14.4
More than 5yrs ago	27	9.1
Never been to dentist	5	1.7
Reason for last dental attendance		
Trouble with teeth/gums	161	54.0
For check-up	60	20.1
Can't remember	32	10.7
Other reason	19	6.4
Ever attended prison dentist		
Yes	148	49.7
No	146	49.0

9.6.6 Dental treatments received

	N (%)		
	Yes	No	Don't know
Fillings	257 (86.2)	26 (8.7)	7 (2.3)
Injection in gum	256 (85.9)	28 (9.4)	7 (2.3)
Injection in arm	43 (14.4)	197 (66.1)	16 (5.4)
X-rays	207 (69.5)	60 (20.1)	19 (6.4)
Extractions	167 (56.0)	69 (23.2)	45 (15.1)
Laughing gas (RA)	82 (27.5)	154 (51.7)	27 (9.1)
Fluoride treatments	55 (18.5)	113 (37.9)	98 (32.9)
Fissure sealants	75 (25.2)	118 (39.6)	62 (20.8)
General anaesthetic	95 (31.9)	130 (43.6)	27 (9.1)
Abscess	120 (40.3)	115 (38.6)	22 (7.4)
Bridge work	30 (10.1)	174 (58.4)	44 (14.8)
Scale and polish	141 (47.3)	94 (31.5)	29 (9.7)
Dentures	55 (18.5)	179 (60.1)	24 (8.1)
Crowns	59 (19.8)	161 (54.0)	31 (10.4)

9.6.7 Dental health-related attitudes

	Definitely feel like that	To some extent	Don't know	Don't feel like that
Toothache: rather take painkillers than go to dentist	60 (20.1)	95 (31.9)	11 (3.7)	130 (43.6)
Worst part of going to dentist is waiting	74 (24.8)	88 (29.5)	20 (6.7)	110 (36.9)
Going to dentist is like being processed on conveyor belt	46 (15.4)	51 (17.1)	50 (16.8)	148 (49.7)
Like to know about what the dentist is doing and why	105 (35.2)	79 (26.5)	26 (8.7)	81 (27.2)
Don't fancy intricate dental treatment	41 (13.8)	57 (19.1)	71 (23.8)	122 (40.9)
Don't like lying in dental chair	28 (9.4)	49 (16.4)	29 (9.7)	186 (62.4)
Find NHS dental treatment difficult to access (outside prison)	53 (17.8)	46 (15.4)	51 (17.1)	139 (46.6)

	N	Percentage (%)
Treatment preference for an aching back tooth		
Filled	203	68.1
Taken out	84	28.2
Treatment preference for front tooth requiring extraction		
Crowned	250	83.9
Taken out	34	11.4
Prison dental service		
Dentist not here enough	145	48.7
Difficult to get an appointment	179	60.1
Don't' like the dentist	25	8.4
Have not been able to get the request form	29	9.7
Difficult to complete the request form	11	3.7
Other	38	12.8

9.6.8 Positive dental related behaviours

	N (%)	
	Home	Prison
Clean teeth with toothbrush and fluoride toothpaste	217 (72.8)	265 (88.9)
Don’t eat sugary foods / drinks between meals	96 (32.2)	115 (38.6)
Clean dentures*	36 (34.6)	48 (24.7)
Leave dentures out at night*	23 (22.1)	32 (30.8)

* *n* = 194 (65.1%) respondents did not wear dentures

9.7 Caries descriptives

9.7.1 Prevalence and severity of dental caries

The cross-tabulation below was compiled to demonstrate the distribution of the different severities of ICDAS *caries* scores recorded at examination. As shown in Figure 1.1 on page 4 of the introductory chapter the severity of caries recorded ranged from earliest experience of visual changes in the enamel (code 1) through to extensive cavitated caries with visible dentine (code 6). Using the ICDAS assessment system, codes 1 and 2 denote reversible disease experience, which could be addressed by preventive therapies such as education interventions, whereas codes 3 to 6 would require dental treatment (e.g. fillings or extraction). One of the early objectives for this thesis was to examine how potential risk factors could vary between those with early stage disease versus those with more severe caries.

Table 9.1 below demonstrates the lack of discrete values for early stage disease (represented as a score of 1 or 2) and the later stages of disease (represented as 3 to 6) in this study population. In this study sample only ten participants were experiencing early stage 'reversible' caries alone. With the number of predictive risk indicators to be analysed this number of observations was too small to allow for comparisons between different stages of caries experience.

Table 9.1 Cross-tabulation of ICDAS caries severity scores

ICDAS caries code*	**3 (*n* = 109)**	**4 (*n* = 99)**	**5 (*n* = 71)**	**6 (*n* = 58)**	**3, 4, 5 or 6 (*n* = 180)**
1 (*n* = 10)	5	6	2	1	**7**
2 (*n* = 54)	35	34	15	12	**46**
1 or 2 (*n* = 61)	39	39	17	13	**<u>51</u>**

* excludes third molars

9.7.2 Caries scores including and excluding third molars

Table 9.2 Prevalence and distribution of total decay experience and caries into dentine scores among all prisoners, 28 and 32 teeth

	Total caries experience (D_1MFT)		Caries into dentine (D_3MFT)	
	Third molars included 32 teeth	**Third molars excluded 28 teeth**	**Third molars included 32 teeth**	**Third molars excluded 28 teeth**
Caries score, N (%)				
0	8 (2.7)	8 (2.7)	12 (4.0)	12 (4.0)
1	3 (1)	3 (1.0)	9 (3.0)	10 (3.4)
2	9 (3)	10 (3.4)	11 (3.7)	10 (3.4)
3	8 (2.7)	8 (2.7)	10 (3.4)	13 (4.4)
4	4 (1.3)	8 (2.7)	18 (6.0)	22 (7.4)
5	22 (7.4)	25 (8.4)	21 (7.0)	24 (8.1)
6	13 (4.4)	14 (4.7)	19 (6.4)	18 (6.0)
7	12 (4)	20 (6.7)	17 (5.7)	16 (5.4)
8	18 (6)	16 (5.4)	15 (5.0)	14 (4.7)
9	17 (5.7)	17 (5.7)	9 (3.0)	12 (4.0)
10	12 (4)	19 (6.4)	11 (3.7)	16 (5.4)
11	18 (6)	21 (7.0)	12 (4.0)	19 (6.4)
12	11 (3.7)	15 (5.0)	12 (4.0)	11 (3.7)
13	17 (5.7)	13 (4.4)	14 (4.7)	13 (4.4)
14	13 (4.4)	16 (5.4)	15 (5.0)	15 (5.0)
15	23 (7.7)	9 (3.0)	12 (4.0)	6 (2.0)
16	8 (2.7)	11 (3.7)	12 (4.0)	8 (2.7)
17	8 (2.7)	8 (2.7)	5 (1.7)	6 (2.0)
18	8 (2.7)	5 (1.7)	7 (2.3)	8 (2.7)
19	7 (2.3)	4 (1.3)	7 (2.3)	4 (1.3)
20	3 (1)	11 (3.7)	4 (1.3)	8 (2.7)
21	4 (1.3)	4 (1.3)	3 (1.0)	4 (1.3)
22	4 (1.3)	6 (2.0)	7 (2.3)	4 (1.3)
23	9 (3)	4 (1.3)	7 (2.3)	2 (0.7)
24	8 (2.7)	2 (0.7)	0 (0.0)	2 (0.7)
25	1 (0.3)	1 (0.3)	5 (1.7)	1 (0.3)
26	6 (2)	0 (0.0)	2 (0.7)	1 (0.3)
27	2 (0.7)	3 (1.0)	1 (0.3)	3 (1.0)
28	2 (0.7)	17 (5.7)	3 (1.0)	16 (5.4)
29	1 (0.3)	-	0 (0.0)	-
30	1 (0.3)	-	4 (1.3)	-
31	3 (1)	-	14 (4.7)	-
32	15 (5)	-	0 (0.0)	-
Mean (*SD*)				
	13.16 (8.14)	11.66 (7.08)	11.63 (8.22)	10.55 (7.38)
Median (25th, 75th percentiles)				
	12 (7, 17)	11 (6, 16)	10 (5, 16)	9 (5, 14)

9.7.3 Caries scores by gender and prison

Table 9.3 Mean and median dental caries scores by gender and prison

Variables	Gender		Prison			Total
	Females*	All males	Cornton Vale*	Shotts	Polmont	
	N = 90	N = 208	N = 90	N = 109	N = 99	**N = 298**
Mean Age (years)	30.89 (10.75)	28.35 (11.36)	30.89 (10.75)	36.23 (10.72)	19.67 (0.89)	29.11 (11.22)
Obvious decay experience including white spot lesions (D_1T)						
Mean (*SD*)	1.94 (2.59)	2.81 (3.25)	1.94 (2.59)	1.59 (2.45)	4.15 (3.49)	2.55 (3.08)
95% CI	1.40, 2.49	2.36, 3.25	1.40, 2.49	1.12, 2.05	3.46, 4.85	2.20, 2.90
Median (IQR)	1 (3.00)	2 (4.75)	1 (3.00)	1 (2.00)	4 (5.00)	1 (4.00)
Maximum	13	14	13	13	14	14
Decay extending into dentine (D_3T)						
Mean (*SD*)	1.08 (1.74)	1.59 (2.27)	1.08 (1.74)	0.99 (1.74)	2.25 (2.58)	1.44 (2.13)
95% CI	0.71, 1.44	1.28, 1.90	0.71, 1.44	0.66, 1.32	1.74, 2.77	1.19, 1.68
Median (IQR)	0 (1.00)	0 (3.00)	0 (1.00)	0 (1.50)	2 (4.00)	0 (2.00)
Maximum	8	12	8	9	12	12
Missing (MT)						
Mean (*SD*)	7.47 (8.07)	5.22 (7.02)	7.47 (8.07)	8.17 (8.22)	1.97 (3.06)	5.90 (7.42)
95% CI	5.78, 9.16	4.26, 6.18	5.78, 9.16	6.60, 9.73	1.36, 2.58	5.05, 6.74
Median (IQR)	4 (9.00)	3 (5.75)	4 (9.00)	5 (8.00)	1 (3.00)	3 (7.00)
Maximum	28	28	28	28	20	28
Filled (FT)						
Mean (*SD*)	3.48 (3.57)	3.10 (3.22)	3.48 (3.57)	4.12 (3.33)	1.98 (2.70)	3.22 (3.33)
95% CI	2.73, 4.23	2.66, 3.54	2.73, 4.23	3.49, 4.75	1.44, 2.52	2.84, 3.59
Median (IQR)	2 (6.25)	2 (5.00)	2 (6.25)	4 (5.00)	1 (3.00)	2 (5.00)
Maximum	13	16	13	16	14	16
Total caries (D_1MFT)						
Mean (*SD*)	12.89 (7.55)	11.13 (6.82)	12.89 (7.55)	13.87 (7.24)	8.10 (4.77)	11.66 (7.08)
95% CI	11.31, 14.47	10.19, 12.06	11.31, 14.47	12.50, 15.25	7.15, 9.05	10.85, 12.47
Median (IQR)	12 (10.50)	10 (9.00)	12 (10.50)	13 (11.00)	8 (6.00)	11 (10.00)
Total caries into dentine (D_3MFT)						
Mean (*SD*)	12.02 (7.92)	9.91 (7.07)	12.02 (7.92)	13.28 (7.32)	6.20 (4.46)	10.55 (7.39)
95% CI	10.36, 13.68	8.94, 10.88	10.36, 13.68	11.89, 14.67	5.31,	9.71, 11.39
Median (IQR)	11 (12.00)	8 (9.00)	11 (12.00)	12 (10.00)	5 (5.00)	9 (9.00)
Caries Free						
n (%)	0 (0.0)	8 (3.8)	0 (0.0)	2 (1.8)	6 (6.1)	8 (2.7)
All 28 teeth affected by caries						
n (%)	8 (8.9)	9 (4.3)	8 (8.9)	9 (8.3)	0 (0.0)	17 (5.7)

* Groups constituted by the same participants

9.7.4 Caries scores by potential risk indicators studied

Table 9.4 Descriptives for socio-demographics and caries experience

		Total caries (D_1MFT)				Caries into dentine (D_3MFT)			
			Percentiles				Percentiles		
Category	**N**	**Mean (*SD*)**	**25th**	**75th**	**Median**	**Mean (*SD*)**	**25th**	**75th**	**Median**
Attained education									
Early school leaver (< 16 yrs)	158	11.89	6	16	11	10.69 (7.62)	5	15	9
Met minimum school leaving age (≥ 16 yrs)	140	11.40	7	15	11	10.39 (7.13)	5	14	10
Employment									
Unemployed/ unable to work	203	12.03 (7.13)	7	16	11	10.87 (7.52)	5	15	9
Employed/ education	90	10.61 (6.71)	6	14	10	9.63 (6.90)	5	13	9
Socio-economic position									
Managerial & professional	5	14.40 (7.96)	10	21	12	13.60 (8.79)	8	21	12
Intermediate	31	10.81 (6.00)	7	15	10	9.35 (6.03)	5	13	8
Routine & manual	31	10.42 (6.31)	5	13	10	9.65 (6.58)	4	13	10
Family & living circumstances									
Marital status									
Single	231	11.32 (6.93)	6	15	10	10.06 (7.23)	5	14	9
Married, cohabiting	33	12.76 (6.42)	7	17	13	11.85 (6.81)	6	17	13
Separated, divorced, widowed	17	15.53 (8.95)	10	23	14	15.41 (8.92)	9	23	14
Shared residence with child(ren)									
No (non-resident parent)	57	13.68 (8.02)	9	20	13	13.02 (8.42)	7	20	13
Yes (resident-parent)	58	12.59 (6.49)	7	17	12	12.03 (6.51)	7	16	11
Has no child	125	9.66 (6.50)	5	12	8	7.98 (6.53)	4	11	6
Stable accommodation									
Accommodation just prior to prison									
Stable	247	11.34 (6.66)	6	15	10	10.21 (6.95)	5	14	9
Non-stable	45	13.93 (8.88)	7	22	12	12.89 (9.33)	5	21	11

		Total caries (D_1MFT)				Caries into dentine (D_3MFT)			
			Percentiles				Percentiles		
Category	**N**	**Mean (*SD*)**	**25th**	**75th**	**Median**	**Mean (*SD*)**	**25th**	**75th**	**Median**
Ever homeless									
No	172	10.82 (5.72)	7	14	11	9.69 (6.06)	5	13	9
Yes	121	12.91 (8.61)	6	20	11	11.83 (8.90)	5	18	10
Length of homelessness									
Less than 6 months	42	10.24 (7.00)	5	13	9	9.10 (6.60)	5	13	7
Between 6 months-1year	34	13.82 (9.34)	5	22	12	12.85 (9.95)	4	22	11
Between 1-2 years	29	13.86 (7.90)	7	22	12	12.59 (8.38)	5	20	11
More than 2 years	16	16.25 (10.74)	5	28	17	15.44 (11.32)	4	28	17
Ever placed 'in care'									
No	176	11.22 (6.53)	6	14	11	10.25 (6.69)	5	14	10
Yes	99	11.86 (7.76)	5	17	10	10.64 (8.24)	4	16	8
Expected length of stay in prison									
Less than 4 years	140	9.96 (6.61)	5	14	9	8.62 (6.84)	4	12	7
More than 4 years	136	13.46 (6.91)	8	18	13	12.52 (7.17)	7	17	12

* Time imprisoned, number sentences, number of remands were analysed as a continuous variables

Table 9.5 Descriptives for health risk behaviours and caries experience

		Total caries (D_1MFT)				Caries into dentine (D_3MFT)			
		Mean	Percentiles				Percentiles		
Category	N	(*SD*)	25th	75th	Median	Mean (*SD*)	25th	75th	Median
Smoked cigarettes									
No	69	9.99 (6.16)	5	14	10	9.10 (6.21)	4	13	8
Yes	224	12.04 (7.21)	7	16	11	10.88 (7.64)	5	15	10
(Illegal) drug use									
No	58	11.31 (7.39)	6	16	11	10.36 (7.63)	4	15	10
Yes	230	11.60 (6.86)	6	15	10	10.43 (7.17)	5	14	9
Intravenous drug use									
No	229	10.43 (6.11)	6	14	10	9.21 (6.26)	4	13	8
Yes	50	16.58 (8.49)	10	26	17	15.96 (8.94)	9	26	16
Participated in drug rehabilitation programme									
No	237	10.81 (6.46)	6	15	10	9.58 (6.69)	4	14	8
Yes	57	15.30 (8.07)	9	23	13	14.61 (8.45)	7	22	13

* Number of cigarettes smoked analysed as a continuous variable

Table 9.6 Descriptives for dental health-related behaviours and caries experience

Category	N	Total caries (D_1MFT)				Caries into dentine (D_3MFT)			
			Percentiles				Percentiles		
		Mean (*SD*)	25th	75th	Median	Mean (*SD*)	25th	75th	Median
Ever attended prison dentist									
No	146	9.68 (6.33)	5	13	9	8.32 (6.50)	4	11	7
Yes	148	13.65 (7.22)	8	19	13	12.76 (7.55)	6	18	12
Attended for a preventive dental treatment*									
No	45	11.93 (7.81)	5	16	11	10.84 (8.25)	4	14	10
Yes	166	12.08 (6.59)	7	16	11	11.13 (6.83)	6	15	11
Time since last dental attendance									
< 6mth	89	12.29 (7.00)	7	17	11	11.19 (7.42)	5	16	11
6mth-1yr	47	11.28 (6.66)	7	14	10	10.04 (6.87)	6	13	8
1-2yrs	85	11.66 (6.94)	6	16	11	10.67 (7.07)	5	15	10
2-5yrs	43	11.60 (6.86)	7	14	11	10.42 (7.40)	5	13	10
>5yrs	27	10.30 (8.59)	5	14	7	9.07 (8.96)	4	11	5
Never attended	5	8.80 (8.70)	1	18	8	7.80 (8.17)	1	16	7
Brushed teeth with fluoride toothpaste									
At Home									
No/Missing	81	13.78 (7.44)	9	19	13	12.81 (7.91)	7	18	12
Yes	217	10.87 (6.79)	6	14	10	9.70 (7.01)	5	14	8
In Prison									
No/ Missing	33	12.12 (9.03)	5	19	11	11.00 (9.46)	3	18	10
Yes	265	11.60 (6.82)	7	16	11	10.49 (7.11)	5	14	9
Avoided sugars between meals									
At Home									
No/Missing	202	12.02 (6.95)	7	16	11	10.90 (7.28)	5	15	10
Yes	96	10.90 (7.32)	5	15	9	9.81 (7.60)	4	14	8
In Prison									
No/Missing	183	11.45 (7.24)	7	15	10	10.37 (7.53)	5	14	9
Yes	115	11.99 (6.84)	6	16	11	10.83 (7.17)	5	15	10

* scale and polish, fissure sealant, or fluoride treatment

9.8 Statistical Analyses Plan

STATISTICAL ANALYSES PLAN

Postgraduate study: T.AKBAR

A) AIMS OF ANALYSIS

1. To document prevalence of dental caries in the prison population of Scotland using data from a cross-sectional survey, conducted in 2011, which specifically included women, youth offenders, and long stay male prisoners;
2. To document the prevalence of known risk indicators for dental caries & test for associations with caries cross-sectionally in the population of study;
3. Explore the prevalence of other potential hypothesised risk indicators for caries and specifically test their association with caries in the population of study;
4. Build predictive model or models if data support different risk indicator experiences in the sub-populations studied
5. Make recommendations for policy

B) STUDY DESIGN

Data is comprised from a cross sectional survey conducted in 3 prison sites in Scotland which constitute three distinct populations: women, young offenders, and long stay male prisoners. Prior to survey, site visits to each location were organised via the healthcare managers of each facility. The prison management subsequently arranged for i) information posters to be displayed the week prior to first survey date and ii) distribution of participation packs (containing participant information sheet, consent form, and data collection instrument) the day just prior to survey.

Specific data items collected are summarised below. All data was recorded on a single data collection form which comprised two sections i) self-report and ii) dental examination. All inmates were eligible for participation with the exception of those who did not understand English and those deemed as high security. All dental examinations were performed by two trained teams of a dentist and a researcher. The examination was performed on all surfaces of all 32 teeth (where present). No radiographs were taken.

During the survey visits, the dental team were allocated a suitable room in each residential hall. The residential prison officers arranged for prisoners to be presented at the examination area for consecutive examinations. Dental examinations continued in each hall visited until all consenting inmates had been examined or until fieldwork ended.

1

C) OUTCOME DATA

Format of raw data:

The International Caries Diagnostic and Assessment System (ICDAS-II) was the main outcome measure of the study. The ICDAS-II data for this survey does not include information for whether the caries present was active or not. Radiographs were not taken and an assessment for dry mouth was not made. The data recorded at time of examination was for *all surfaces* of 32 teeth (where present). A 2 digit code recording system was used where:

- First digit = Caries Code. Caries (decay) experience recorded on an ordinal scale. Possible values range from 0 to 6, where 0 is sound and 1 to 6 is caries present (higher score indicates more severe caries).
- Second digit = Restorations (fillings) or sealants present as a categorical value.
- Additional to the above, two digit tertiary codes for missing surfaces was used e.g. 97 = missing due to caries.

Data manipulation for statistical analyses:

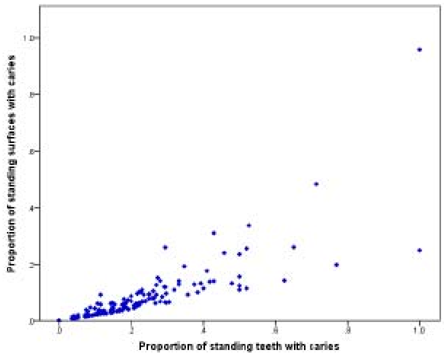
The ICDAS-II data was converted to the World Health Organization (WHO) DMFT Index. In brief, the surface level data was aggregated to tooth level by scoring each tooth for presence of decay at D1, presence of decay at D3, presence of filling, or presence of missing dentition. (Where a tooth is both decayed and filled it is recorded as decayed). From this data it is possible to determine the total number of teeth with decay at D1, decay at D3, restorations, and missing dentition.

We are going to use D1MFT and D3MFT both as continuous scores and binary summaries. The ICDAS-II values mapped across to D1MFT and D3MFT are presented in the table below. If there is time we will also examine D2MFT.

ICDAS-II Codes	DMF Index		
Caries	**Decayed (D1)**	**Decayed (D2)**	**Decayed (D3)**
0 – Sound	×	×	×
1 - First change in enamel	✓	×	×
2 - Distinct visual change in enamel	✓	×	×
3 - Enamel breakdown, no dentine visible	✓	✓	×
4 - Underlying dentinal shadow	✓	✓	✓
5 - Distinct cavity	✓	✓	✓
6 - Extensive distinct cavity	✓	✓	✓
Missing	**Missing**		
93 – pontic placed for carious reasons	✓	✓	✓
97 – tooth extracted as a result of caries	✓	✓	✓
Restorations	**Filling**		
3 – tooth coloured restoration	✓	✓	✓
4 – amalgam restoration	✓	✓	✓
5 – stainless steel crown	✓	✓	✓
6 – porcelain,, gold, PFM crown or veneer	✓	✓	✓
7 – Lost or broken restoration	✓	✓	✓
8 – temporary restoration	✓	✓	✓

Detailed steps in data manipulation:

i) Comparison surfaces/teeth: to determine if aggregating the scores to tooth level resulted in any loss of data the number of decayed surfaces (D1S) were compared with number of decayed teeth (D1T); it was determined there was no significant loss of data when converting to number of teeth(see figure below) therefore the analyses will be limited to DMFT as the outcome variable (to be annotated in methods).



ii) Unerupted third molars: 12.5% (37) of examined participants had at least one un-erupted third molar; to control for variation the statistical analyses was restricted to scores for 28 teeth (to be annotated in technical appendix).

D) INTERMEDIATE EXPLANATORY/OUTCOME VARIABLE EXCLUDED

Visible plaque was recorded in the original survey however ascertaining the low risk group in the study population presented difficulties since we cannot reliably know that a person is controlling low plaque levels on a continual basis over time. A decision was taken to exclude plaque from the present study.

E) EXPLANATORY VARIABLES/ RISK INDICATORS

Category	Established: non-prisoner populations and/or prisons population	Established: *only* in non-prison population	Potential
Socio-demographics	Age; Sex; Ethnicity;		Prison (location)
Social economic occupational position	Employment (yes/no);	Economic position	
Education	Education;		
Community: stable accommodation / social care	Ever been placed in care; Ever been homeless; Length of homelessness;		Accommodation just prior to prison;
Family support		Marital status; Resided with children;	Have children; Number of children;
Time exposed to prison environment	Time spent in prison; Duration current imprisonment;		Number of times imprisoned remand; Number times sentenced;
Dry mouth	Dry mouth**		
Common risk factor health conditions	Markers of common risk factors		
Health risk behaviours	Smoking; Number cigarettes; Nicotine (smoking+tobacco); Substance use; Injecting drug use; Drug rehabilitation programme;		
Dental health behaviours	Toothbrushing (home and prison); Frequency dental attendance;	Sugar consumption (home and prison); Preventive treatments received;	Attended prison dentist;
Dental health attitudes		Reason for last dental attendance; Treatment preferences – back tooth & front tooth;	
Psychosocial measures	Dental anxiety; Depression;		

* Health indications (diabetes, angina, heart attack, blood pressure, infectious disease, asthma/lung disease, epilepsy and pregnancy) were recorded however at best we can only conclude these are indicators/markers of other unmeasured risk factors e.g. health behaviours, treatment/medications which affect oral environment, genetics etc.

** The possibility of dry mouth has been determined by reviewing medicines reported to see if dry mouth is indicated as side effect according to BNF. There is some bias here particularly as an effect was recorded irrespective of whether the side effect was common, uncommon or frequency unknown (BNF).

F) STATISTICAL ANALYSES STEPS

- Outcomes for main analyses: D1MFT, D3MFT (stored as both continuous and binary)

1. Descriptive analyses: point prevalence of outcomes

OUTPUT: tabulations, boxplots, charts of outcomes by age and sex.

2. Univariable analyses: compare each explanatory variable with outcomes

   a. Unadjusted (Spearman rho, Wilcoxon-Mann-Whitney and Kruskal Wallis tests)
   b. Age / Sex adjusted (weighted linear regression)

Weighted linear regression method has been chosen to allow for non-constant variance. This non-constant variance was identified by a triangular shape in the plot of the residuals against the fitted values obtained from the regression of the dental scores against continuous age. Weighted regression, using the rreg command in STATA, gives less weight to observations with higher residual standard deviations and ignores extreme outliers with a Cook's distance greater than 1, i.e. observations where value of the explanatory variable are far from its mean and the point has a big effect on the regression coefficients.

OUTPUT: summary of risk indicator / covariate distributions by outcome status for:

   i) Whole population
   ii) Separately by prison population i.e. women, adult males, male young offenders

3. Multiple regression models (logistic and linear)

The output from step 2 above will be used to filter the potential list of explanatory variables to those significantly related to either of the outcomes (Wald test $p<0.10$). The following forward and backward selection methods will then be used to identify the "best" model for each outcome.

In backward selection, each explanatory variable is assessed in turn and the one which is least significant and $p>0.10$ is removed - the process is repeated until the remaining variables are significant at the chosen level of $p<0.10$.

In the forward selection, the variables removed in the preceding step (backward selection) are re-introduced and in order of their significance in the univariable analyses. At each addition the model fit is assessed and these steps are repeated until the model is no longer improved.

OUTPUT: summarise relationship with coefficients and odds ratios for continuous and binary outcomes respectively (will include p-values)

4. Population study: to establish if a different model fits the different sub-populations of study

   a. Analyses will be repeated in each prison sub-group separately.
   b. Repeated for all prisoners adjusting for age, sex and prison (sex and prison in this study translate being female and being young offender)

OUTPUT: graphs / histograms / bar charts to support the above analyses. Summary of key relationships/model(s) found.

9.9 Additional analyses

9.9.1 Non-parametric tests of association between potential risk indicators

Due to the large number of potential risk indicators under consideration, and their related nature, there was a high likelihood of severe intra-correlation (multicollinearity) which, if not addressed, could adversely influence the effect sizes calculated in the multiple robust regression models. To identify strongly associated variables, non-parametric tests of association between each pair of potential risk indicators were calculated. Tabulations of the statistical test results are reported in this Appendix. The findings are reported in Part 2 of the study results – see section 4.5.

The Spearman rank-order correlation coefficient (r_s) and its associated p-value was calculated for pairs of continuous and/or binary variables. P-values of < 0.05 were used to confirm statistically significant associations where r_s of 0.80-1.0 were considered 'very strong', 0.60-0.79 were 'strong' and 0.40-0.59 were 'moderate'. The results for the whole study population are reported in Appendix Table 9.7.

Kruskal Wallis test (H) (also called "one-way ANOVA on ranks") was calculated to assess associations ($p < 0.05$) between a categorical and a continuous or ordinal measure. The results are reported in Appendix Table 9.8.

The chi-square (χ^2) test of independence was used to compare a categorical with another categorical or binary variable. The χ^2 and p-values are reported for the overall population analyses however, where limited observations resulted in cells with expected counts less than 5, the Fishers exact p-value is reported. P-values of < 0.05 were used to confirm correlated relationships. Results for associations between marital status and other potential risk indicators are reported in Appendix Table 9.9, between the measure capturing parenthood and shared residence with child(ren) in Appendix Table 9.10, and between reason for last dental attendance and other potential risk indicators in Appendix Table 9.11.

Table 9.7 Correlation matrix for spearman rank order tests between pairs of continuous or binary potential risk indicators

	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11	v12	v13	v14	v15	v16	v17	v18	v19	v20	v21	v22	v23	v24	v25	v26	v27	v28	v29	v30	v31
v1	1.00																														
v2	0.159**	1.00																													
v3	0.141*	0.03	1.00																												
v4	-0.01	0.116*	-0.192**	1.00																											
v5	-0.02	0.125*	-0.162**	0.161**	1.00																										
v6	-0.04	0.05	-0.10	0.131*	0.952**	1.00																									
v7	-0.05	0.253**	-0.208**	0.395**	0.134*	0.130*	1.00																								
v8	-0.01	0.277**	-0.229**	0.394**	0.152**	0.144*	0.958**	1.00																							
v9	-0.159**	-0.02	-0.179**	0.171**	0.124*	0.11	0.166**	0.12	1.00																						
v10	0.558**	-0.206**	0.05	-0.09	-0.11	-0.11	-0.185**	-0.204**	-0.02	1.00																					
v11	0.568**	-0.321**	0.144*	-0.155*	-0.169**	-0.124*	-0.235**	-0.244**	-0.12	0.770**	1.00																				
v12	0.10	-0.244**	-0.134*	0.10	0.10	0.10	0.04	0.06	0.290**	0.166*	0.07	1.00																			
v13	0.162*	-0.221**	-0.11	0.05	0.208**	0.215**	0.06	0.06	0.317**	0.218**	0.189**	0.704**	1.00																		
v14	0.152*	0.158*	0.03	0.05	0.05	0.06	0.283**	0.279**	0.05	0.01	-0.03	-0.01	-0.08	1.00																	
v15	0.317**	0.229**	-0.09	0.06	0.09	0.06	0.207**	0.207**	0.04	0.121*	0.10	0.10	0.09	0.221**	1.00																
v16	-0.09	0.02	-0.07	0.11	0.164**	0.165**	0.00	0.03	0.212**	-0.09	-0.120*	0.156*	0.171*	0.00	0.123*	1.00															
v17	-0.01	0.01	-0.11	0.135*	0.174**	0.149*	0.09	0.11	0.262**	0.01	-0.08	0.12	0.174*	0.09	0.175**	0.758**	1.00														
v18	-0.209**	-0.200**	-0.131*	0.02	0.11	0.10	0.05	0.02	0.257**	-0.07	-0.133*	0.330**	0.212**	0.04	0.09	0.405**	0.288**	1.00													
v19	0.201**	0.248**	-0.09	0.143*	0.07	0.06	0.399**	0.412**	0.10	-0.01	-0.04	0.257**	0.169*	0.279**	0.441**	0.136*	0.166**	0.245**	1.00												
v20	0.182**	0.168**	0.09	0.142*	0.00	-0.01	0.212**	0.213**	0.10	0.10	0.04	0.223**	0.157*	0.152*	0.271**	0.185**	0.262**	0.253**	0.488**	1.00											
v21	0.374**	-0.06	0.01	-0.11	0.02	-0.02	-0.136*	-0.140*	0.07	0.584**	0.420**	0.237**	0.250**	0.07	0.144*	-0.03	0.01	0.08	0.11	0.175**	1.00										
v22	0.12	0.11	-0.01	-0.12	-0.153*	-0.187**	-0.05	-0.06	-0.04	0.11	0.14	-0.13	-0.04	-0.174*	0.163*	-0.01	-0.04	0.08	0.08	0.04	0.198**	1.00									
v23	-0.03	-0.09	-0.06	0.10	0.04	0.03	0.07	0.11	-0.01	-0.191**	-0.10	0.08	0.05	-0.01	-0.05	0.00	0.00	-0.05	-0.01	-0.07	-0.364**	-0.340**	1.00								
v24	-0.238**	0.221**	0.00	-0.04	-0.03	0.00	0.02	0.03	0.08	-0.241**	-0.259**	-0.09	-0.12	-0.125*	-0.05	0.00	-0.05	0.06	-0.01	-0.01	-0.126*	0.05	0.08	1.00							
v25	-0.01	-0.05	-0.01	-0.03	-0.03	0.00	-0.03	-0.03	0.03	0.04	0.04	-0.01	0.01	-0.02	0.04	0.04	-0.01	0.07	-0.06	-0.02	0.08	0.03	-0.04	0.10	1.00						
v26	-0.07	0.219**	-0.03	-0.07	-0.03	-0.07	0.09	0.06	0.01	-0.11	-0.155**	-0.11	-0.05	-0.07	-0.06	-0.08	-0.07	-0.08	0.01	-0.06	-0.08	0.07	0.130*	0.340**	-0.05	1.00					
v27	0.08	0.02	-0.01	-0.11	-0.07	-0.04	0.00	-0.02	0.02	0.06	0.03	-0.09	-0.03	0.00	-0.03	-0.04	-0.04	-0.09	-0.06	-0.09	0.02	0.06	0.02	-0.166**	0.192**	0.324**	1.00				
v28	0.123*	0.136*	-0.122*	0.05	0.01	0.02	0.09	0.139*	-0.06	-0.03	-0.03	0.08	0.161*	0.10	0.08	0.06	0.03	-0.08	0.148*	0.02	0.02	-0.165*	0.133*	0.01	-0.140*	0.04	-0.04	1.00			
v29	0.06	0.03	-0.131*	0.06	0.06	0.06	0.10	0.138*	0.07	0.00	-0.01	0.02	0.07	0.02	-0.02	-0.01	-0.03	-0.10	0.02	-0.03	0.08	-0.158*	0.03	0.00	-0.10	0.03	0.05	0.482**	1.00		
v30	-0.01	0.295**	-0.10	0.12	0.07	-0.02	0.194**	0.215**	0.240**	-0.13	-0.215**	-0.09	0.04	0.203**	0.167*	0.191**	0.259**	0.03	0.07	0.01	-0.04	-0.03	-0.01	0.04	0.12	-0.01	0.00	0.07	0.01	1.00	
v31	-0.04	0.167**	0.03	0.01	0.06	0.03	0.129*	0.133*	0.05	-0.03	-0.09	-0.01	0.02	0.04	0.11	0.05	0.09	0.01	0.04	0.07	0.00	-0.05	0.04	0.11	0.03	0.02	-0.05	0.01	0.03	0.142*	1.00

* r_s *p*-value is significant at the 0.05 level (2-tailed) ** r_s *p*-value is significant at the 0.01 level (2-tailed)

v1=Age (years); v2=Female sex; v3=completed mandatory education; v4=non-stable accomodation; v5=employed/education; v6=social occupational classification; v7=ever homeless; v8=homeless length; v9=placed in care as child/teenager; v10=time imprisoned (years); v11=sentence length >4 years; v12=number of remands; v13=number of sentences; v14=health condition with shared common risk factors; v15=medicinal-related dry mouth indicated; v16=smoked cigarettes; v17=number cigarettes smoked per day; v18=ever used any (illegal) drugs; v19=ever used intravenous drugs; v20=participated in drug rehabilitation programme; v21=ever attended prison dentist; v22=ever attended for preventive dental treatment; v23=time since last dental attendance; v24=used toothbrush & fluoride toothpaste at home; v25=used toothbrush & fluoride toothpaste in prison; v26=avoided sugars between meals at home; v27=avoided sugars between meals in prison; v28=prefer treatment for back tooth; v29=prefer treatment for front tooth; v30=depression (CES-D) score; v31=dental anxiety (MDAS) score

Key	0.80	0.60	0.40	0.20	0.15	0.00	-0.15	-0.20	-0.40	-0.60	-0.80

Table 9.8 Kruskal Wallis tests of association between categorical and continuous or ordinal potential risk measures

		All prisoners		Females		Long-stay adult males		Male young offenders	
Potential risk indicators compared	*df*	*H statistic*	*P*-value	*H statistic*	*P*-value	*H statistic*	*P*-value	*H statistic*	*P*-value
Age (years)									
Marital status	2	34.99	**<0.001**	9.51	**0.009**	18.55	**<0.001**	2.70	0.259
Parenthood & shared residence	2	67.04	**<0.001**	14.68	**0.001**	6.99	0.030	4.35	0.114
Reason for last dental attendance	2	7.26	**0.026**	0.34	0.843	2.20	0.333	0.06	0.970
Standard Occupational Classification									
Marital status	2	1.85	0.396	4.06	0.131	0.07	0.968	0.27	0.873
Parenthood & shared residence	2	2.44	0.295	4.91	0.086	4.30	0.116	1.30	0.552
Reason for last dental attendance	2	1.42	0.491	0.97	0.616	2.15	0.342	1.00	0.607
Length of homelessness									
Marital status	2	2.15	0.342	0.57	0.754	7.11	**0.029**	4.03	**0.045**
Parenthood & shared residence	2	3.11	0.211	6.54	**0.038**	9.82	**0.007**	5.74	0.057
Reason for last dental attendance	2	4.41	0.110	7.81	**0.020**	6.73	**0.035**	1.37	0.505
Time imprisoned (years)									
Marital status	2	3.91	0.142	0.46	0.795	5.79	0.055	3.08	0.214
Parenthood & shared residence	2	14.84	**0.001**	0.99	0.609	6.89	**0.032**	0.29	0.863
Reason for last dental attendance	2	14.79	**0.001**	2.08	0.353	3.13	0.209	2.41	0.300
Number sentences									
Marital status	2	0.01	0.995	0.46	0.797	0.10	0.950	0.09	0.769
Parenthood & shared residence	2	1.07	0.585	3.52	0.172	0.19	0.911	1.34	0.513
Reason for last dental attendance	2	1.29	0.524	1.84	0.398	2.16	0.340	3.99	0.136
Number times remanded									
Marital status	2	2.46	0.292	3.35	0.187	1.17	0.556	1.29	0.525
Parenthood & shared residence	2	0.42	0.813	0.78	0.677	0.63	0.731	2.61	0.271
Reason for last dental attendance	2	0.32	0.852	3.30	0.192	1.65	0.438	3.03	0.219
Number cigarettes smoked per day									
Marital status	2	2.12	0.346	0.86	0.649	4.86	0.088	1.00	0.606
Parenthood & shared residence	2	1.48	0.477	1.69	0.430	0.06	0.972	5.96	0.051
Reason for last dental attendance	2	5.31	0.070	2.84	0.242	1.46	0.481	4.37	0.112

Continued on next page

Potential risk indicators compared	df	All prisoners *H statistic*	*P*-value	Females *H statistic*	*P*-value	Long-stay adult males *H statistic*	*P*-value	Male young offenders *H statistic*	*P*-value
Time since last dental attendance									
Marital status	2	0.15	0.929	1.02	0.602	0.15	0.929	0.24	0.886
Parenthood & shared residence	2	3.49	0.175	2.43	0.297	1.45	0.484	3.55	0.170
Reason for last dental attendance	2	0.45	0.798	0.26	0.880	0.90	0.639	2.17	0.337
Depression (CES-D score)									
Marital status	2	7.08	**0.029**	4.65	0.098	5.43	0.066	2.43	0.297
Parenthood & shared residence	2	0.57	0.754	0.92	0.631	0.71	0.703	4.28	0.118
Reason for last dental attendance	2	2.03	0.363	1.00	0.607	4.16	0.125	3.08	0.214
Dental anxiety (MDAS score)									
Marital status	2	2.78	0.249	1.41	0.494	0.94	0.625	2.54	0.281
Parenthood & shared residence	2	2.89	0.236	3.07	0.215	8.43	**0.015**	0.57	0.753
Reason for last dental attendance	2	1.41	0.494	1.90	0.387	2.83	0.243	2.53	0.282

Table 9.9 Chi-square tests of independence: associations between marital status and other potential risk indicators, by prison

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	Single, cohabiting *n* (%)**	Married, cohabiting *n* (%)**	Separated, widowed, divorced *n* (%)**	Total *n**	χ^2 *(df)*	*p*-value	*p*-value*	*p*-value*	*p*-value*
Gender					1.54 (2)	0.464	-	-	-
Male	162 (70)	25 (76)	10 (59)	197					
Female	69 (30)	8 (24)	7 (41)	84					
Education					8.86 (2)	**0.012**	0.174	0.184	0.527
Early school leaver	127 (55)	17 (52)	3 (18)	147					
Met school leaving age	104 (45)	16 (49)	14 (82)	134					
Unemployed					-	0.560*	0.124	1.000	1.000
No	66 (30)	11 (34)	6 (38)	83					
Yes	162 (71)	21 (66)	10 (63)	193					
Shared residence with child(ren)					-	**<0.001***	0.199	**0.005**	0.109
No child	112 (62)	9 (27)	1 (6)	122					
Non-resident parent	38 (21)	8 (24)	8 (47)	54					
Resident parent	30 (17)	16 (49)	8 (47)	54					
Community accommodation just prior to prison					-	0.169*	0.882	0.273	1.000
Stable	187 (83)	31 (94)	15 (94)	233					
Non-stable	39 (17)	2 (6)	1 (6)	42					
Homeless					2.26 (2)	0.323	0.430	0.072	0.086
No	130 (57)	22 (69)	11 (69)	163					
Yes	98 (43)	10 (31)	5 (31)	113					
Placed in care					2.44 (2)	0.296	0.413	0.821	0.529
No	129 (62)	25 (76)	11 (65)	165					
Yes	80 (38)	8 (24)	6 (35)	94					
Length stay in prison					11.68 (2)	**0.003**	0.387	0.715	1.000
< 4 years	118 (55)	8 (28)	4 (25)	130					
> 4 years	98 (45)	21 (72)	12 (75)	131					

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	Single, cohabiting *n* (%)**	Married, cohabiting *n* (%)**	Separated, widowed, divorced *n* (%)**	Total *n**	χ^2 *(df)*	*p*-value	*p*-value*	*p*-value*	*p*-value*
Health condition(s)					5.50 (2)	0.064	0.894	0.189	0.679
No	102 (51)	13 (39)	2 (18)	117					
Yes	99 (49)	20 (61)	9 (82)	128					
Medicinal-related dry mouth potentially indicated					-	**0.010***	0.102	0.528	0.376
No	178 (77)	18 (55)	10 (59)	206					
Yes	53 (23)	15 (46)	7 (41)	75					
Smokes cigarettes					-	0.051*	0.364	**0.012**	0.678
No	47 (21)	13 (41)	3 (18)	63					
Yes	180 (79)	19 (59)	14 (82)	213					
Any (illegal) drug use					-	**0.001***	0.587	**0.002**	0.426
No	35 (16)	11 (36)	7 (44)	53					
Yes	191 (85)	20 (65)	9 (56)	220					
Intravenous drug use					-	0.692*	0.436	0.366	1.000
No	179 (83)	24 (77)	13 (81)	216					
Yes	37 (17)	7 (23)	3 (19)	47					
Drug rehabilitation programme					-	0.631*	0.378	0.740	1.000
No	179 (79)	27 (84)	15 (88)	221					
Yes	49 (22)	5 (16)	2 (12)	56					
Attended prison dentist					0.12 (2)	0.943	0.838	0.539	0.230
No	111 (49)	16 (49)	9 (53)	136					
Yes	117 (51)	17 (52)	8 (47)	142					
Attended for preventive dental treatment					-	0.245*	0.659	0.152	1.000
No	35 (22)	3 (11)	4 (33)	42					
Yes	125 (78)	25 (89)	8 (67)	158					

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	Single, cohabiting *n* (%)**	Married, cohabiting *n* (%)**	Separated, widowed, divorced *n* (%)**	Total *n**	χ^2 *(df)*	*p*-value	*p*-value*	*p*-value*	*p*-value*
Reason for most recent dental attendance					-	0.873*	0.300	0.735	0.779
Problem with teeth/gums	127 (68)	18 (64)	11 (79)	156					
Check-up	46 (25)	7 (25)	3 (21)	56					
Other reason	15 (8)	3 (11)	0 (0)	18					
Clean teeth with fluoride toothpaste (at home)					-	0.163*	1.000	0.387	1.000
No	59 (26)	12 (36)	7 (41)	78					
Yes	172 (75)	21 (64)	10 (59)	203					
Clean teeth with fluoride toothpaste (in prison)					-	0.934*	1.000	0.448	1.000
No	26 (11)	4 (12)	2 (12)	32					
Yes	205 (89)	29 (88)	15 (88)	249					
Avoid sugars between meals (at home)					0.08 (2)	0.959	1.000	0.560	1.000
No	158 (68)	22 (67)	12 (71)	192					
Yes	73 (32)	11 (33)	5 (29)	89					
Avoid sugars between meals (in prison)					3.08 (2)	0.214	0.767	0.195	0.173
No	144 (62)	21 (64)	7 (41)	172					
Yes	87 (38)	12 (36)	10 (59)	109					
Prefer extraction: back tooth					-	0.773*	0.728	0.934	0.238
No	160 (72)	21 (66)	11 (69)	192					
Yes	63 (28)	11 (34)	5 (31)	79					
Prefer extraction: front tooth					-	0.873*	0.546	0.343	1.000
No	191 (87)	29 (88)	16 (94)	236					
Yes	28 (13)	4 (12)	1 (6)	33					

* Fishers exact *p*-value (2-sided); ** *n* (absolute), proportions do not always total 100% due to rounding

Table 9.10 Chi-square tests of independence: associations between parenthood, shared residence and other potential risk indicators, by prison

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	No child *n* (%)	Non-resident parent *n* (%)	Resident parent *n* (%)	Total *n*	χ^2 *(df)*	*p*-value	*p*-value*	*p*-value*	*p*-value*
Gender					1.43 (2)	0.490	-	-	-
Male	93 (74)	48 (76)	39 (67)	180					
Female	32 (26)	15 (24)	19 (33)	66					
Education					5.70 (2)	0.058	0.902	**0.014**	0.474
Early school leaver	71 (57)	37 (59)	23 (40)	131					
Met school leaving age	54 (43)	26 (41)	35 (60)	115					
Unemployed					3.46 (2)	0.177	**0.046**	χ^2 = 6.14 (2)	0.547
No	39 (32)	18 (29)	24 (44)	81				*p* =**0.048**	
Yes	85 (69)	45 (71)	31 (56)	161					
Marital status					-	**<0.001***	0.199	**0.005**	0.109
Single	112 (92)	38 (70)	30 (56)	180					
Married, cohabiting	9 (7)	8 (15)	16 (30)	33					
Separated, widowed, divorced	1 (1)	8 (15)	8 (15)	17					
Community accommodation just prior to prison					7.72 (2)	**0.021**	0.167	**0.007**	0.440
Stable	99 (81)	51 (82)	55 (97)	205					
Non-stable	23 (19)	11 (18)	2 (4)	36					
Homeless					2.67 (2)	0.264	χ^2 = 5.19 (2)	χ^2 = 8.89 (2)	**0.035**
No	72 (59)	35 (57)	40 (70)	147			*p* = 0.074	*p* =**0.013**	
Yes	51 (42)	26 (43)	17 (30)	94					
Placed in care					3.93 (2)	0.140	0.618	0.371	0.084
No	68 (58)	41 (66)	41 (73)	150				χ^2 = 1.99 (2)	
Yes	49 (42)	21 (34)	15 (27)	85				*p* = 0.371	
Length stay in prison					30.06 (2)	**<0.001**	0.398	0.337	0.467
< 4 years	78 (70)	24 (41)	16 (28)	118					
> 4 years	34 (30)	35 (59)	41 (72)	110					

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	No child *n* (%)	Non-resident parent *n* (%)	Resident parent *n* (%)	Total *n*	χ^2 *(df)*	*p*-value	*p*-value*	*p*-value*	*p*-value*
Health condition(s)					4.52 (2)	0.105	0.051	χ^2 = 1.10 (2) *p* = 0.594	**0.021**
No	60 (55)	23 (43)	19 (38)	102					
Yes	50 (46)	31 (57)	31 (62)	112					
Medicinal-related dry mouth potentially indicated					7.20 (2)	**0.027**	χ^2 = 1.67 (2) *p* = 0.470	χ^2 = 0.46 (2) *p* = 0.798	0.072
No	104 (83)	43 (68)	40 (69)	187					
Yes	21 (17)	20 (32)	18 (31)	59					
Smokes cigarettes					2.45 (2)	0.294	1.000	χ^2 = 0.56 (2) *p* = 0.761	0.069
No	24 (20)	13 (21)	17 (32)	54					
Yes	98 (80)	50 (79)	40 (70)	188					
Any (illegal) drug use					3.90 (2)	0.142	0.393	0.050	0.709
No	19 (17)	16 (27)	14 (25)	49					
Yes	103 (84)	44 (73)	42 (75)	189					
Intravenous drug use					4.71 (2)	0.095	0.363	0.733	0.112
No	103 (90)	45 (78)	45 (82)	193					
Yes	12 (10)	13 (22)	10 (18)	35					
Drug rehabilitation programme					1.35 (2)	0.510	0.345	0.194	1.000
No	105 (85)	53 (86)	45 (79)	203					
Yes	18 (15)	9 (15)	12 (21)	39					
Attended prison dentist					4.76 (2)	0.092	χ^2 = 1.05 (2) *p* = 0.644	χ^2 = 0.69 (2) *p* = 0.786	0.594
No	72 (59)	28 (45)	26 (45)	126					
Yes	50 (41)	34 (55)	32 (55)	116					
Attended for preventive dental treatment					0.09 (2)	0.957	1.000	0.864	0.732
No	19 (23)	8 (21)	11 (23)	38					
Yes	65 (77)	31 (80)	37 (77)	133					

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	No child *n* (%)	Non-resident parent *n* (%)	Resident parent *n* (%)	Total *n*	χ^2 *(df)*	*p*-value	*p*-value*	*p*-value*	*p*-value*
Reason for most recent dental attendance					-	0.085*	0.242	0.129	0.686
Problem with teeth/gums	61 (60)	38 (81)	36 (72)	135					
Check-up	29 (28)	6 (13)	12 (24)	47					
Other reason	12 (12)	3 (6)	2 (4)	17					
Clean teeth with fluoride toothpaste (at home)					6.93 (2)	**0.031**	0.367	χ^2 = 0.52 (2) *p* = 0.826	0.219
No	25 (20)	23 (37)	19 (33)	67					
Yes	100 (80)	40 (64)	39 (67)	179					
Clean teeth with fluoride toothpaste (in prison)					0.89 (2)	0.642	0.842	0.480	1.000
No	14 (11)	7 (11)	4 (7)	25					
Yes	111 (89)	56 (89)	54 (93)	221					
Avoid sugars between meals (at home)					2.68 (2)	0.262	χ^2 = 1.50 (2) *p* = 0.496	0.900	0.624
No	80 (64)	47 (75)	42 (72)	169					
Yes	45 (36)	16 (25)	16 (28)	77					
Avoid sugars between meals (in prison)					0.77 (2)	0.680	χ^2 = 1.28 (2) *p* = 0.573	χ^2 = 0.43 (2) *p* = 0.826	0.758
No	81 (65)	38 (60)	34 (59)	153					
Yes	44 (35)	25 (40)	24 (41)	93					
Prefer extraction: back tooth					5.17 (2)	0.075	0.135	χ^2 = 0.35 (2) *p* = 0.903	0.053
No	96 (79)	40 (65)	38 (69)	174					
Yes	25 (21)	22 (36)	17 (31)	17					
Prefer extraction: front tooth					4.87 (2)	0.088	**0.028**	0.906	0.187
No	109 (92)	50 (82)	52 (93)	211					
Yes	10 (8)	11 (18)	4 (7)	25					

* Fishers exact *p*-value, unless otherwise stated; *n* (absolute, proportions do not always total 100% due to rounding)

Table 9.11 Chi-square tests of independence: associations between reason for last dental attendance and other potential risk indicators, by prison

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	Trouble with teeth/gums *n* (%)	Check-up *n* (%)	'Other' reasons *n* (%)	Total *n*	χ^2 (*df*)	*p*-value	*p*-value*	*p*-value*	*p*-value*
Gender					8.99 (2)	**0.011**	-	-	-
Male	121 (75)	34 (57)	16 (84)	171					
Female	40 (25)	26 (43)	3 (16)	69					
Education					3.19 (2)	0.203	0.775	0.270	χ^2 = 6.98 (2) *p* = **0.033**
Early school leaver	89 (55)	26 (43)	8 (42)	123					
Met school leaving age	72 (45)	34 (57)	11 (58)	117					
Unemployed					1.31 (2)	0.521	0.900	0.442	0.313
No	52 (33)	20 (35)	4 (21)	76					
Yes	108 (68)	37 (65)	15 (79)	160					
Marital status					-	0.873*	0.300	0.735	0.779
Single	127 (81)	46 (82)	15 (83)	188					
Married, cohabiting	18 (12)	7 (13)	3 (17)	28					
Separated, widowed, divorced	11 (7)	3 (5)	0 (0)	14					
Shared residence with child(ren)					-	0.085*	0.242	0.129	0.686
No child	61 (45)	29 (62)	12 (71)	102					
Non-resident parent	38 (28)	6 (13)	3 (18)	47					
Resident parent	36 (27)	12 (26)	2 (12)	50					
Community accommodation just prior to prison					-	0.552*	0.249	0.383	1.000
Stable	138 (87)	49 (82)	15 (83)	202					
Non-stable	21 (13)	11 (18)	3 (17)	35					
Homeless					2.52 (2)	0.284	0.370	0.141	0.573
No	101 (64)	37 (63)	8 (44)	146					
Yes	58 (37)	22 (37)	10 (56)	90					

Potential risk indicator compared	All prisoners (**N** = 298)						Females (**N** = 90)	Long-stay adult males (**N** = 109)	Male young offenders (**N** = 99)
	Trouble with teeth/gums *n* (%)	Check-up *n* (%)	'Other' reasons *n* (%)	Total *n*	χ^2 *(df)*	*p*-value	*p*-value*	*p*-value*	*p*-value*
Placed in care					2.90 (2)	0.234	0.052	0.131	χ^2 = 0.20 (2)
No	97 (64)	37 (70)	8 (47)	142					*p* = 0.942
Yes	54 (36)	16 (30)	9 (53)	79					
Length stay in prison					6.37 (2)	**0.041**	0.338	1.000	1.000
< 4 years	66 (43)	27 (50)	14 (74)	107					
> 4 years	86 (57)	27 (50)	5 (26)	118					
Health condition(s)					4.14 (2)	0.126	0.206	0.567	0.139
No	71 (50)	30 (60)	5 (31)	106					
Yes	70 (50)	20 (40)	11 (69)	101					
Medicinal-related dry mouth potentially indicated					-	0.448*	0.231	**0.031**	0.168
No	123 (76)	49 (82)	13 (68)	185					
Yes	38 (24)	11 (18)	6 (32)	55					
Smokes cigarettes					-	0.389*	1.000	0.717	0.281
No	34 (22)	17 (29)	3 (16)	54					
Yes	124 (79)	42 (71)	16 (84)	182					
Any (illegal) drug use					-	**0.034***	0.189	0.334	0.191
No	26 (17)	19 (32)	2 (11)	47					
Yes	129 (83)	41 (68)	17 (90)	187					
Intravenous drug use					-	0.876*	0.597	0.126	0.650
No	128 (84)	46 (82)	14 (82)	188					
Yes	24 (16)	10 (18)	3 (18)	37					
Drug rehabilitation programme					-	1.000*	0.300	0.510	0.349
No	129 (80)	48 (81)	15 (79)	192					
Yes	32 (20)	11 (19)	4 (21)	47					
Attended prison dentist					11.43 (2)	**0.003**	0.305	**0.020**	0.941
No	64 (40)	38 (64)	11 (61)	113					
Yes	95 (60)	21 (36)	7 (39)	123					

Potential risk indicator compared	All prisoners (*N* = 298)						Females (*N* = 90)	Long-stay adult males (*N* = 109)	Male young offenders (*N* = 99)
	Trouble with teeth/gums *n* (%)	Check-up *n* (%)	'Other' reasons *n* (%)	Total *n*	χ^2 (*df*)	*p*-value	*p*-value*	*p*-value*	*p*-value*
Attended for preventive dental treatment					-	0.626*	1.000	0.819	0.622
No	23 (21)	11 (22)	1 (8)	35					
Yes	87 (79)	40 (78)	12 (92)	139					
Clean teeth with fluoride toothpaste (at home)					2.38 (2)	0.320	0.795	0.107	0.505
No	43 (27)	20 (33)	3 (16)	66					
Yes	118 (73)	40 (67)	16 (84)	174					
Clean teeth with fluoride toothpaste (in prison)					-	0.401*	0.445	0.138	1.000
No	18 (11)	3 (5)	2 (11)	23					
Yes	143 (89)	57 (95)	17 (90)	217					
Avoid sugars between meals (at home)					2.51 (2)	0.285	1.000	0.856	0.497
No	111 (69)	39 (65)	16 (84)	166					
Yes	50 (31)	21 (35)	3 (16)	74					
Avoid sugars between meals (in prison)					5.44 (2)	0.066	0.341	0.300	0.058
No	92 (57)	38 (63)	16 (84)	146					
Yes	69 (43)	22 (37)	3 (16)	94					
Prefer extraction: back tooth					8.31 (2)	**0.016**	**0.045**	0.710	0.170
No	104 (67)	46 (79)	18 (95)	168					
Yes	51 (33)	12 (21)	1 (5)	64					
Prefer extraction: front tooth					-	0.884*	1.000	0.774	1.000
No	139 (89)	50 (89)	18 (95)	207					
Yes	17 (11)	6 (11)	1 (5)	24					

* Fishers exact *p*-value; *n* (absolute, proportions do not always total 100% due to rounding)

9.9.2 Non-parametric tests of association between potential risk indicators and caries outcome scores

This following text accompanies the results reported in section 4.6. To assess associations between dental caries outcome scores and each of the potential risk indicators, standard non-parametric bivariate tests were first calculated prior to the "univariable" robust linear regression models adjusted for age, (and gender for *all* prisoners combined). The findings for the regression analysis are not considered here but are detailed in the main text (section 4.6).

The non-parametric bivariate tests were less sensitive than robust linear regression (i.e. less likely to detect association between dental score and potential risk indicator) but could not be adjusted for age. In some instances a significant association was found in the non-parametric tests ($p < 0.05$) but was not sustained in the corresponding age adjusted robust regression; these results could be attributed to confounding by age and are reported here.

Detailed methods for the non-parametric tests are reported in the study methods – see section 3.9.2, page 81. In brief, the tests varied depending on the potential risk indicator under investigation and included: Spearman rank order correlation (r_s) to correlate pairs of continuous or ordinal variables, Wilcoxon rank sum (Mann-Whitney) test (Z) to compare the binary variables with dental scores, and finally the Kruskal-Wallis test (H) to compare variables with three or more groupings (categorical). For all three tests, *p*-values < 0.05 were taken as evidence of significant associations.

Tabulations for all three tests statistics and their associated *p*-values are reported in Appendix Table 9.12 for D_1MFT scores and Appendix Table 9.13 for D_3MFT scores. The following page summarizes the results for indications of confounding by age.

9.9.2.1 Confounding by age (and gender): shared residence with children

For the analyses of all prisoners combined, D_1MFT scores significantly differed between childless participants (mean rank = 105), parents who shared residence with their children (mean rank = 139) and parents living in separate residences from children (mean rank = 145) (Kruskal Wallis rank test, $H(2) = 16.96$, $p < 0.001$). D_3MFT scores also significantly differed between the three groups ($H(2) = 27.61$, $p < 0.001$), with mean ranks of 100, 147, and 149 for childless prisoners, parents sharing residence, and parents separated respectively. However, participants with no child were also younger ($\bar{x} = 23$ years) when compared with parents sharing residence ($\bar{x} = 35$ *years)* and parents separated ($\bar{x} = 34$ years) and after adjusting for age and gender (robust linear regression) the apparent differences in dental scores were no longer significant (D_1MFT $p = 0.505$; D_3MFT $p = 0.605$).

Similarly, for female prisoners alone, D_1MFT scores significantly differed between the three groups ($H(2) = 11.49$, $p = 0.003$), with mean ranks of 27, 34 and 47 for childless females, mothers sharing residence, and mothers living in separated residences respectively. Again females with no child were younger ($\bar{x} = 25$ years) than resident mothers ($\bar{x} = 31$ years) or separated mothers ($\bar{x} = 38$ years) and the differences in D_1MFT scores were not apparent after adjustment for age ($p = 0.124$).

9.9.2.2 Confounding by age (and gender): prison experiences

A review of the findings for D_1MFT scores for all prisoners combined identified four prison-related measures (time imprisoned, length of prison term > 4years, number of remands, and number of sentences) where scores significantly differed in the non-parametric tests (see Table 9.12); however after adjustment for age and gender all four were not significant (see Table 4.10, page 124). For D_3MFT scores, significant findings for three measures (length of prison term > 4years, number of remands, and number of sentences) disappeared after adjustment for age and gender (see Table 9.13 for non-parametric test results and Table 4.11 for adjusted robust regression).

When examined by prison, for adult males, D_1MFT and D_3MFT scores significantly differed by time imprisoned (D_1MFT $r_s = 0.252$, $p = 0.009$; D_3MFT $r_s = 0.295$, $p = 0.002$), number of remands (D_1MFT $r_s = 0.325$, $p = 0.003$; D_3MFT $r_s = 0.325$, $p = 0.003$) and number of sentences (D_1MFT $r_s = 0.313$, $p = 0.003$; D_3MFT $r_s = 0.313$, $p = 0.003$). Whereas after adjustment for age there was no apparent difference in the outcome scores (see Table 4.10 and Table 4.11 for adjusted robust regression results). In the adult male population, age was significantly associated with time imprisoned ($r_s = 0.241$, $p = 0.013$) however it was not possible to detect a significant association between age and number of remands ($r_s = 0.184$, $p = 0.098$) or sentences ($r_s = 0.096$, $p = 0.374$).

Similarly, for male young offenders, D_1MFT scores were significantly associated with time imprisoned ($r_s = 0.281$, $p = 0.007$) however after adjustment for age no significant ($p = 0.533$) difference was apparent. For male young offenders, the older offenders were significantly more likely to have spent more time in prison ($r_s = 0.217$, $p = 0.038$).

9.9.2.3 Confounding by age and gender: xerostomia indicated

For all prisoners combined, D_1MFT scores were significantly higher ($Z = -3.12$, $p = 0.001$) among prisoners where medicinal-related dry mouth (xerostomia) was indicated, mean ranks 178 compared with 139 for no indication of dry mouth. Similarly, for all prisoners, D_3MFT scores were also significantly higher ($Z = -3.80$, $p < 0.001$) with mean rank of 182 for the group with medicinal-related dry mouth potentially indicated, compared with mean rank 138 for the group where dry mouth not indicated. However, in this population older prisoners were significantly more likely to have medicinal-related dry mouth potentially indicated ($r_s = 0.317$, $p < 0.001$), and females were more likely to have dry mouth potentially indicated ($r_s = 0.229$, $p < 0.001$); thus D_1MFT and D_3MFT scores could be explained by age and gender and the apparent association with an indication of medicinal-related dry mouth were no longer significant after adjustment for age and gender (D_1MFT $p = 0.254$; D_3MFT $p = 0.192$).

9.9.2.4 Confounding by age: attendance prison dentist

Among female prisoners, attendance at the prison dentist was associated with significantly higher D_1MFT scores higher ($Z = -2.35$, $p = 0.019$), mean 52 for those who had attended compared with 39 for those who had not attended prison dentist. However, after adjustment for age D_1MFT scores did not significantly differ between the two groups ($p = 0.123$). In the female population those who had attended the prison dentist were older ($\bar{x} = 34$ years) when compared with female prisoners who had not attended ($\bar{x} = 29$ years). It is also of note that D_3MFT scores were also significantly higher among females ($Z = -2.63$, $p = 0.009$) and these scores were also higher in the age adjusted regression analyses although only significant at $p < 0.1$ ($p = 0.093$).

9.9.2.5 *Confounding by age (and gender): toothbrushing in home setting*

For all prisoners combined, D_1MFT scores were significantly lower (D_1MFT $Z = -3.36$, $p = 0.001$) among prisoners who brushed their teeth with fluoride toothpaste in the home setting when compared to those who did not, mean ranks 139 and 177 respectively. Similarly, for all prisoners, D_3MFT scores were also significantly lower ($Z = -3.21$, $p = 0.001$) with mean ranks of 140 vs 176 respectively. However, in this population older prisoners were significantly less likely to have brushed their teeth in the home setting ($r_s = -0.238$, $p < 0.001$), and females significantly more likely to have brushed their teeth when compared with males ($r_s = 0.221$, $p < 0.001$); thus D_1MFT and D_3MFT scores could be explained by age and gender and the apparent associations with toothbrushing in the home setting were no longer significant after adjustment for age and gender (D_1MFT $p = 0.264$; D_3MFT $p = 0.323$).

For the adult male prison population D_1MFT scores were also significantly lower ($Z = -3.13$, $p = 0.002$) with mean ranks of 47 and 66 for those who did and did not brush their teeth with fluoride toothpaste in the home setting respectively. Again, amongst this population older age was associated with not brushing teeth in home setting and, when adjusted for age, the apparent difference in scores no longer significantly differed ($p = 0.103$).

9.9.2.6 *Confounding by age and gender): dental treatment preferences for back tooth*

For all prisoners significantly higher D_3MFT scores were evident for those who preferred extraction for a back tooth ($Z = -1.97$, $p = 0.049$) with mean rank of 159 compared with 138 for those who preferred to have their tooth filled. However, preferences for dental treatment could also be explained by age ($r_s = 0.123$, $p = 0.038$) and gender ($r_s = 0.136$, $p = 0.022$) and the apparent association between D_3MFT scores and preferences for back tooth requiring treatment disappeared after adjustment for age and gender (robust regression $p = 0.167$; see Table 4.11).

Table 9.12 Non-parametric bivariate tests of association for each potential risk indicators and D_1MFT scores

Potential risk indicator	All prisoners		Females		Adult males		Male young offenders	
	Test statistic*	*p*-value	Test statistic*	*p*-value	Test statistic*	*p*-value	Test statistic*	*p*-value
Age (years)	0.546	**<0.001**	0.585	**<0.001**	0.519	**<0.001**	0.045	0.657
Female	-1.836	0.066	-	-	-	-	-	-
Standard occupational classification (SOC)	0.043	0.475	0.119	0.275	0.194	0.059	-0.168	0.108
Unemployed	-1.611	0.107	-1.384	0.166	-1.877	0.060	-0.118	0.906
Met school leaving age (16yrs)	-0.206	0.837	-0.141	0.888	-0.868	0.385	-0.223	0.824
Marital status	6.316 (2)	0.043	1.036 (2)	0.596	1.641 (2)	0.440	0.379 (2)	0.827
Shared residence with child(ren)	16.956 (2)	**<0.001**	11.492 (2)	**0.003**	0.463 (2)	0.793	1.261 (2)	0.532
Non-stable accommodation just prior to prison	1.503	0.133	-0.478	0.632	3.536	**<0.001**	-0.258	0.796
Ever homeless	-1.292	0.197	-0.082	0.934	-2.833	**0.005**	-0.916	0.360
Length of homelessness	0.118	**0.044**	0.084	0.431	0.329	**0.001**	-0.098	0.344
Placed 'in care' as child/teenager	-0.072	0.943	-0.244	0.807	-2.009	**0.044**	-0.058	0.954
Time imprisoned (years)	0.350	**<0.001**	0.206	0.076	0.252	**0.009**	0.281	**0.007**
Length current stay in prison >4 years	-4.537	**<0.001**	-1.665	0.096	-0.279	0.788	-1.903	0.057
Number of times remanded in prison	0.179	**0.005**	0.163	0.187	0.318	**0.004**	0.060	0.566
Number of times sentenced in prison	0.187	**0.006**	0.296	**0.028**	0.326	**0.002**	-0.149	0.211
Health condition with shared common risk factors	-3.436	**0.001**	-1.379	0.168	-3.559	**<0.001**	-0.215	0.830
Medicinal related dry mouth potentially indicated	-3.319	**0.001**	-2.418	**0.016**	-0.616	0.538	-1.169	0.242
Smoking cigarettes	-1.741	0.082	-2.236	**0.025**	-2.115	**0.034**	-0.397	0.692
Number cigarettes smoked per day	0.183	**0.002**	0.259	**0.019**	0.302	**0.002**	0.072	0.486
Ever used any (illegal) drug	-0.290	0.772	-1.333	0.182	-0.617	0.537	-0.204	0.838
Ever used intravenous drugs	-4.710	**<0.001**	-2.779	**0.005**	-3.294	**0.001**	0.020	**0.013**
Participated in drug rehabilitation programme	-3.657	**<0.001**	-2.019	**0.043**	-2.050	**0.040**	0.048	0.962
Attended prison dentist	-4.791	**<0.001**	-2.350	**0.019**	-1.511	0.131	-1.685	0.092

Continued on next page

Potential risk indicator	All prisoners		Females		Adult males		Male young offenders	
	Test statistic*	*p*-value	Test statistic*	*p*-value	Test statistic*	*p*-value	Test statistic*	*p*-value
Attended for preventive dental treatment	-0.628	0.530	-1.516	0.130	-1.866	0.062	-0.195	0.845
Time since last dental attendance	-0.090	0.120	-0.156	0.143	0.064	0.510	-0.135	0.184
Avoid sugar between meals at home	-1.676	0.094	-0.514	0.607	-1.962	**0.050**	-1.877	0.061
Avoid sugar between meals in prison	-0.790	0.429	-0.049	0.961	-0.396	0.692	-0.562	0.574
Toothbrush and fluoride toothpaste at home	-3.363	**0.001**	-0.025	0.980	-3.127	**0.002**	-0.790	0.430
Toothbrush and fluoride toothpaste in prison	-0.099	0.921	-0.250	0.803	-0.978	0.328	-0.229	0.819
Reason for last dental attendance	6.990 (2)	**0.030**	6.068 (2)	**0.048**	0.480 (2)	0.786	0.972 (2)	0.615
Prefer extraction for back tooth requiring filling	-1.878	0.060	-3.008	**0.003**	-0.302	0.762	-1.127	0.260
Prefer extraction for front tooth needing crowned	-1.877	0.065	-2.616	**0.009**	-0.366	0.714	-0.986	0.324
Depression (CES-D score)	0.035	0.591	-0.008	0.951	0.170	0.116	-0.071	0.526
Dental anxiety (MDAS score)	0.066	0.270	0.123	0.271	-0.062	0.534	0.146	0.152

* Spearman rank order correlation (r_s), continuous or ordinal potential risk indicator; Wilcoxon rank sum (Mann-Whitney) test (Z), binary variables; Kruskal-Wallis test (H), categorical variables (three or more groupings), degrees of freedom are reported in parenthesis

Table 9.13 Non-parametric bivariate tests of association for each potential risk indicators and D_3MFT score

Potential risk indicator	All prisoners		Females		Adult males		Male young offenders	
	Test statistic	*p*-value	Test statistic	*p*-value	Test statistic	*p*-value	Test statistic	*p*-value
Age (years)	0.630	**<0.001**	0.652	**<0.001**	0.549	**<0.001**	0.077	0.449
Female gender	-2.169	0.030	-	-	-	-	-	-
Standard occupational classification (SOC)	0.033	0.585	0.121	0.266	0.189	0.065	-0.177	0.092
Unemployed	-1.202	0.229	-1.420	0.156	-1.887	0.059	-0.355	0.722
Met school leaving age (16yrs)	-0.083	0.934	-0.121	0.904	-0.641	0.522	-0.372	0.710
Marital status	8.989 (2)	**0.011**	1.879 (2)	0.391	2.247 (2)	0.325	1.618 (2)	0.445
Shared residence with child(ren)	27.609 (2)	**<0.001**	13.189 (2)	**0.001**	0.449 (2)	0.799	1.413 (2)	0.493
Non-stable accommodation just prior to prison	1.451	0.147	-0.756	0.450	3.518	**<0.001**	0.385	0.700
Ever homeless	-1.245	0.213	-0.837	0.403	-2.887	**0.004**	-0.066	0.947
Length of homelessness	0.108	0.064	0.007	0.947	0.331	**<0.001**	-0.005	0.959
Placed 'in care' as child/teenager	-0.270	0.787	-0.288	0.773	-2.185	**0.029**	-0.602	0.547
Time imprisoned (years)	0.398	**<0.001**	0.237	0.041	0.295	**0.002**	0.205	0.050
Length current stay in prison >4 years	-4.967	**<0.001**	-1.934	0.053	-0.093	0.929	-0.518	0.605
Number of times remanded in prison	0.158	**0.014**	0.145	0.243	0.325	**0.003**	0.030	0.775
Number of times sentenced in prison	0.181	**0.008**	0.336	**0.012**	0.313	**0.003**	-0.177	0.136
Health condition with shared common risk factors	-4.056	**<0.001**	-1.133	0.257	-4.146	**<0.001**	-0.901	0.367
Medicinal related dry mouth potentially indicated	-3.800	**<0.001**	-2.492	**0.013**	-0.514	0.607	-0.685	0.494
Smoking cigarettes	-1.373	0.170	-2.188	**0.029**	-2.112	**0.035**	-1.079	0.280
Number cigarettes smoked per day	0.139	**0.020**	0.245	**0.027**	0.303	**0.002**	-0.052	0.613
Ever used any (illegal) drug	-0.268	0.788	-1.435	0.151	-0.986	0.324	-0.309	0.757
Ever used intravenous drugs	-4.883	**<0.001**	-2.730	**0.006**	-3.303	**0.001**	-1.889	0.058
Participated in drug rehabilitation programme	-4.013	**<0.001**	-2.019	**0.043**	-2.214	**0.027**	-0.425	0.671
Attended prison dentist	-5.265	**<0.001**	-2.630	**0.009**	-2.089	**0.037**	-0.933	0.351

Continued on next page

Potential risk indicator	All prisoners		Females		Adult males		Male young offenders	
	Test statistic	*p*-value	Test statistic	*p*-value	Test statistic	*p*-value	Test statistic	*p*-value
Attended for preventive dental treatment	-0.860	0.390	-1.665	0.096	-2.080	**0.038**	-0.368	0.713
Time since last dental attendance	-0.095	0.102	-0.182	0.087	0.036	0.707	-0.058	0.573
Avoid sugar between meals at home	-1.461	0.144	-0.344	0.731	-2.110	**0.035**	-1.333	0.183
Avoid sugar between meals in prison	-0.809	0.419	-0.186	0.853	-0.363	0.717	-0.585	0.559
Toothbrush and fluoride toothpaste at home	-3.209	**0.001**	-0.370	0.711	-3.356	**0.001**	-0.369	0.712
Toothbrush and fluoride toothpaste in prison	-0.378	0.706	-0.261	0.794	-1.088	0.276	-0.587	0.557
Reason for last dental attendance	6.509 (2)	**0.039**	4.318 (2)	0.115	0.441 (2)	0.802	0.356 (2)	0.837
Prefer extraction for back tooth requiring filling	-1.967	**0.049**	-2.779	**0.005**	-0.440	0.660	-1.025	0.305
Prefer extraction for front tooth needing crowned	-1.646	0.100	-2.479	**0.013**	-0.554	0.580	-0.671	0.502
Depression (CES-D score)	0.042	0.519	-0.049	0.696	0.186	0.085	-0.039	0.731
Dental anxiety (MDAS score)	0.058	0.331	0.089	0.428	-0.084	0.397	0.164	0.106

* Spearman rank order correlation (r_s), continuous or ordinal potential risk indicator; Wilcoxon rank sum (Mann-Whitney) test (*Z*), binary variables; Kruskal-Wallis test (*H*), categorical variables (three or more groupings), degrees of freedom are reported in parenthesis

9.9.3 Social engagement data excluded from study measures

Whilst exploring the data it was hoped the analyses could include an analysis of the relationship between social engagement and dental caries. A proxy variable was created from the employment & education data where the grouping categories were i) unemployed, ii) engaged in full-time activity, iii) engaged in part-time activity, iv) casual work, and v) unable to work. A Kruskal Wallis test showed the mean ranks of total caries (D_1MFT) scores were not significantly different between these groups of differing social engagement ($H(4) = 3.020$, $p = 0.5545$), similar non-significant findings were determined for caries into dentine (D_3MFT) mean ranks ($H(4) = 3.222$, $p = 0.5214$). However since the survey question these data were derived from did not allow inference for timeframe spent engaged in activities the proxy variable was deemed unreliable to assess the effect of social engagement.

9.9.4 Dentures worn

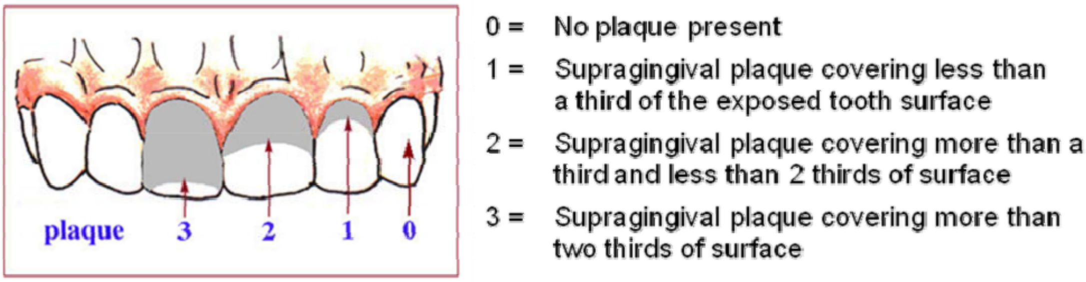
At the time of dental examination 15% (45) of participants were wearing a denture; of these 12 prisoners were edentate. Eighty percent (36) wore an upper denture, 2% (1) wore a lower denture and 18% (8) had both upper and lower dentures.

Fifty-two percent (23) of upper dentures, were partial, 48% (21) were complete dentures. The majority of upper dentures examined were plastic (40) and a small number were metallic (4). Whilst the majority of upper dentures were intact (89%), 11% (4) were in need of repair. Twenty-six (74%) upper dentures were tissue borne, six were tooth borne (17%) and three (9%) were both tissue and tooth borne.

Most of the lower dentures observed were complete (8); one participant wore a partial lower denture. All lower dentures (9) were composed of plastic. One participant had a denture in need of repair. Four lower dentures were determined to be tissue borne.

9.9.5 Plaque scores

The calculus or dental plaque was measured according to the DHSRU plaque index criteria shown in the figure below. Six teeth were scored, where present, in the participants dentition: upper and lower right 6^{th}, upper and lower left 6^{th}, and the upper and lower 1^{st}. A total score was subsequently calculated by adding the values together and dividing by the number of surfaces scored therefore the final plaque score ranged from 0 to 3.



In the present study, the total mean plaque score, for the 280 recorded entries, was 0.77 (*SD* = 0.81). Mean plaque score for the upper teeth was 0.71 (*SD* = 0.81) and for the lower 0.78 (*SD* = 0.88).

9.9.6 Post-hoc power analyses

Post-hoc analyses were conducted to assess the power to detect (1) differences in dental scores amongst the full sample of approximately 300 individuals, and (2) differences amongst the full sample of 300 individuals, and the prison-specific (sub-population) analyses when adjusted for the number of possible indicators considered.

9.9.6.1 Detecting differences in dental scores amongst all prisoners

The following analyses were conducted with the STATA 14 programme [9] named SIMPOWER which uses Monte Carlo simulation to derive post hoc power estimates for means, standard deviations and sample sizes for one-way ANOVAs.

For the aggregate D_1MFT and D_3MFT data (dental scores examined within the thesis), it can be seen, from the output below, that for the highlighted alpha level of 0.05 the power to test for two-sided statistical significance is well beyond the conventional 80% in all cases. For example, the D_1MFT data produce an estimated power of 100% to correctly identify a significant effect at the 5% level.

[9] StataCorp. 2015. *Stata Statistical Software: Release 14.* College Station, TX: StataCorp LP.

************ for D_1MFT DATA***********

. simpower, gr(3) n(100 100 100) mu(13.87 12.89 8.10) s(7.24 7.55 4.77)

```
Sample Sizes, Means and Standard Deviations
-------------------------------------------
N1 = 100     MU1 = 13.87     S1 = 7.24
N2 = 100     MU2 = 12.89     S2 = 7.55
N3 = 100     MU3 = 8.1       S3 = 4.77
Total N = 300

 1000 simulated ANOVA F tests
------------------------------
 Alpha   Simulated
 Level     Power
------------------------------
 0.1000   1.0000
 0.0750   1.0000
 0.0500   1.0000
 0.0250   1.0000
 0.0100   1.0000
```

************ for D_3MFT DATA***********

. simpower, gr(3) n(100 100 100) mu(13.28 12.02 6.20) s(7.32 7.92 4.46)

```
Sample Sizes, Means and Standard Deviations
-------------------------------------------
N1 = 100     MU1 = 13.28     S1 = 7.32
N2 = 100     MU2 = 12.02     S2 = 7.92
N3 = 100     MU3 = 6.2       S3 = 4.46
Total N = 300

 1000 simulated ANOVA F tests
------------------------------
 Alpha   Simulated
 Level     Power
------------------------------
 0.1000   1.0000
 0.0750   1.0000
 0.0500   1.0000
 0.0250   1.0000
 0.0100   1.0000
```

9.9.6.2 Detecting differences in dental scores amongst all prisoners, adjusted for number of potential risk indicators

Linear multiple regression analyses were undertaken using the G*Power programme [10] (version 3.1.9.2): F statistical test for fixed model, R^2 increase.[11] The analysis was structured assuming a baseline model of age + gender (all prisoners analyses) or age alone (prison-specific [sub-population] analyses), and where the R^2 for each baseline model was 0.32. Multiple analyses were performed to allow for potential indicators with varying effect sizes (corresponding to improvements in R^2 of 0.03 to 0.05). The nominal alpha level of 0.05 was considered for the all prisoners analyses (Figure 9.1) with further Bonferroni adjustment, to account for multiple testing (wherein type 1 error is increased i.e. increased probability of incorrectly rejecting a true null hypothesis, or a "false positive") in the prison-specific analyses, by using alpha = 0.05/3 (Figure 9.2). Whilst accurate power calculations should allow for correlations between predictors in the model (and not just the number of hypotheses tested), for the purposes of illustration, the total number of predictors considered in the regression model were equivalent to entering only one variable from each set of highly correlated variables examined in the thesis. Therefore, 28 potential risk indicators were considered, giving a total of 30 predictors (including age and gender) in the analysis of all prisons combined, and 29 variables (including age but not gender) in the prison-specific analyses.

As shown in Figure 9.1 there was sufficient power (approximately 95%), in the analysis of all prisons combined, to test the main effects of predictors with moderate effect sizes (corresponding to R^2 increase of 0.04), and, the power was reduced to approximately 85% where effect sizes were small (i.e. R^2 increase of 0.03). However, as illustrated in Figure 9.2, the power to detect interactions between potential predictors of large effect sizes (i.e. R^2 increase of 0.05) will be much lower (approximately 25%). Thus the results of the prison-specific analyses should be interpreted with caution.

[10] Power Analysis Using G*Power. UCLA: Statistical Consulting Group. from http://www.ats.ucla.edu/stat/gpower/ (accessed February 07, 2017).

[11] Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41, 1149-1160.

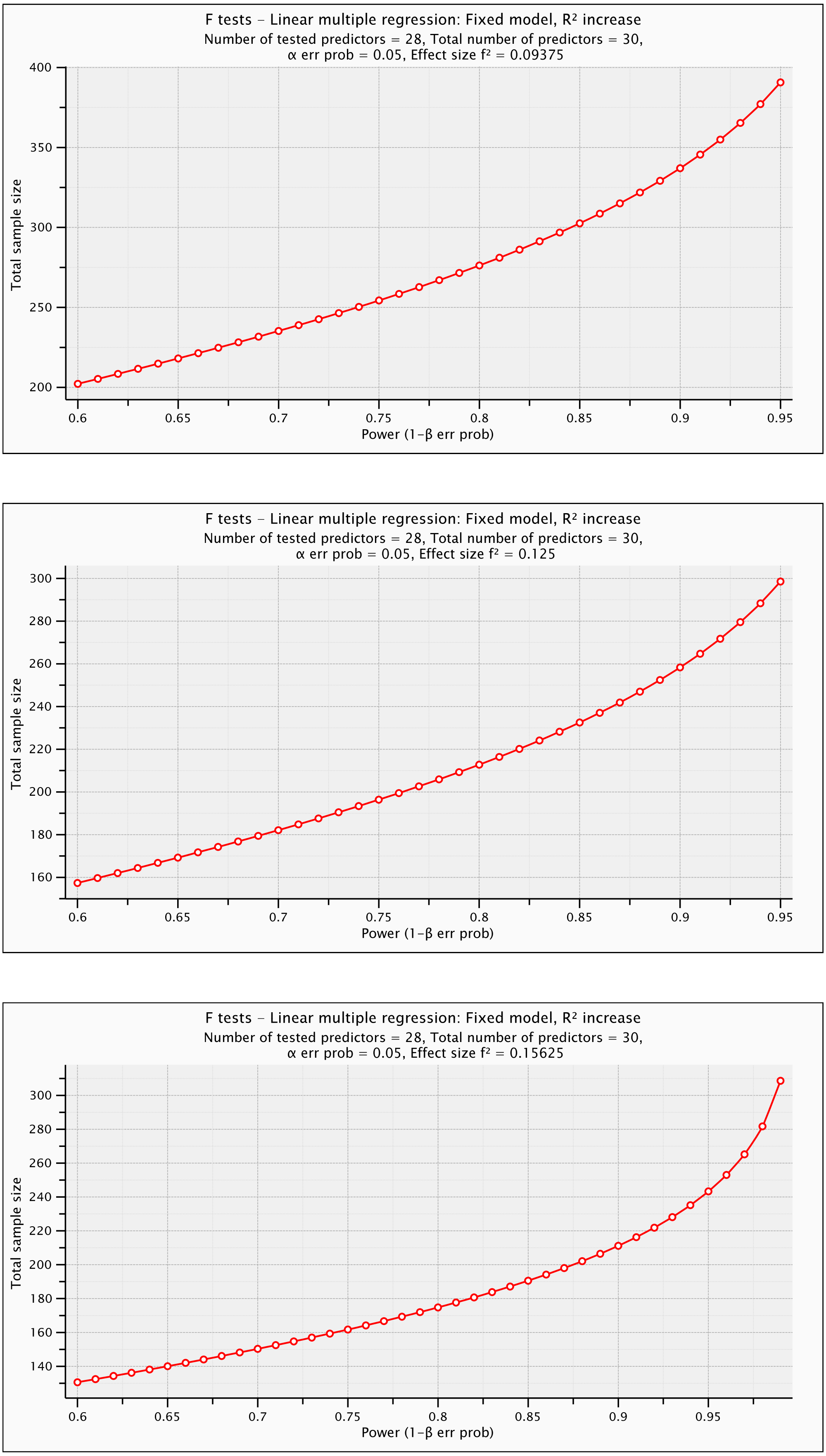


Figure 9.1 **All prisoners combined, impact of varying effect sizes on power**

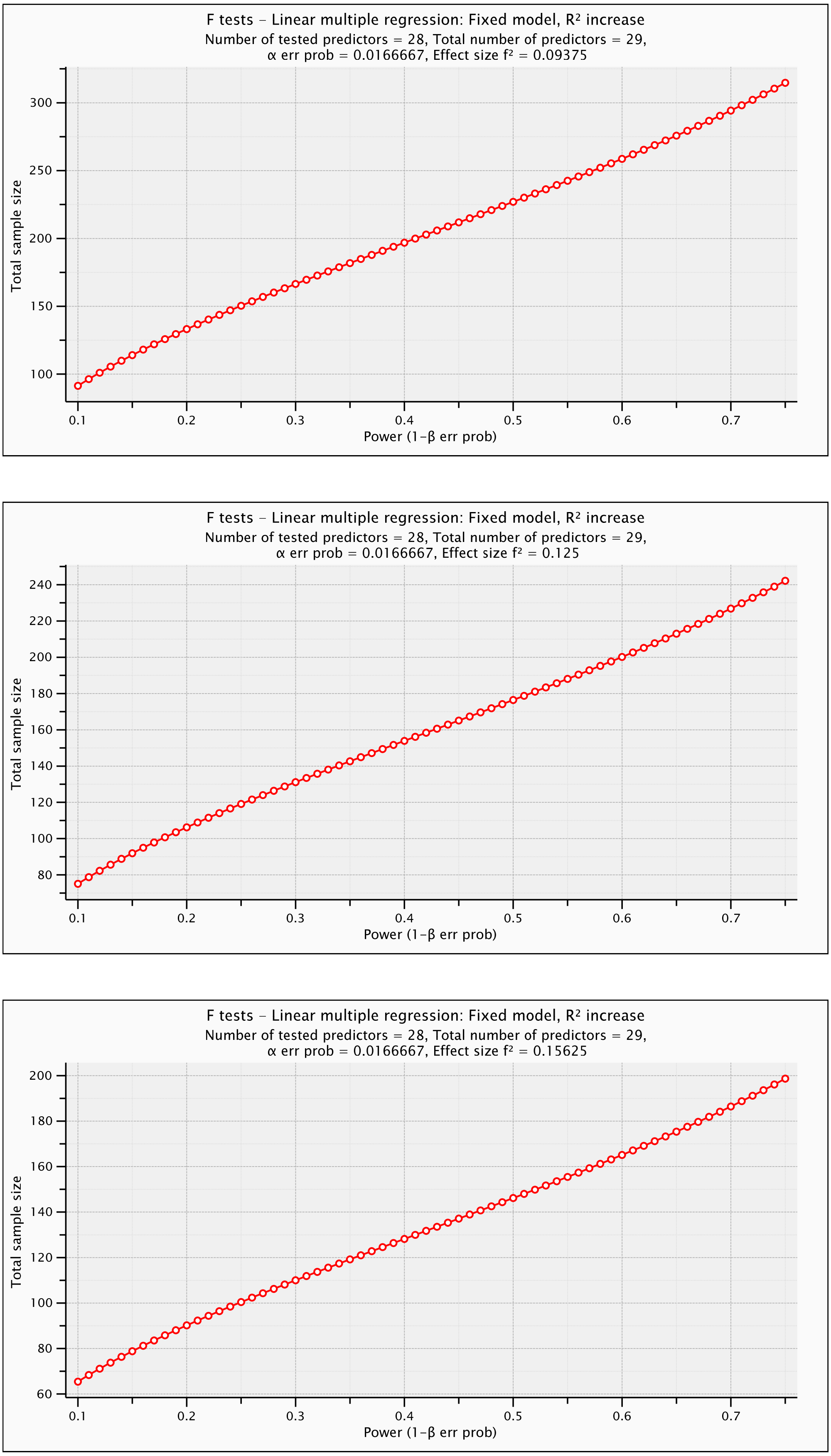


Figure 9.2 Sub-population analyses, impact of varying effect sizes on power